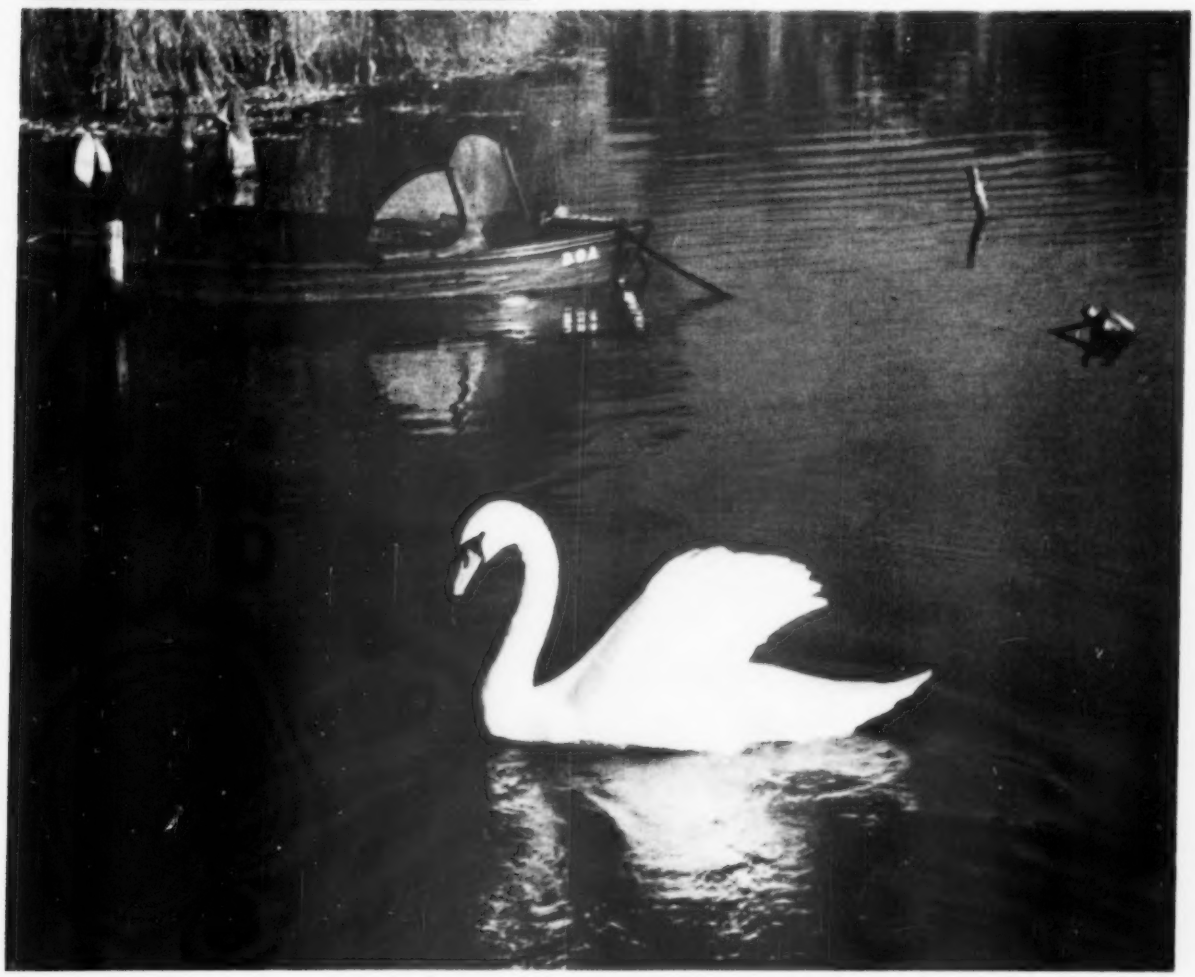
AUTOMOBILE ENGINEER

DESIGN · PRODUCTION · MATERIALS

Vol. 50 No. 8 AUGUST 1960 PRICE: 3s. 6d.

MIDCYL RESEARCH helps smooth out problems



life for the Auto Engineer is not always placid, but the continued research of Midcyl helps to smooth out such of his problems as are associated with Cylinder Blocks, Cylinder Heads, Camshafts and Brake Drums

MIDCYL

THE MIDLAND MOTOR CYLINDER CO. LTD., SMETHWICK, STAFFS

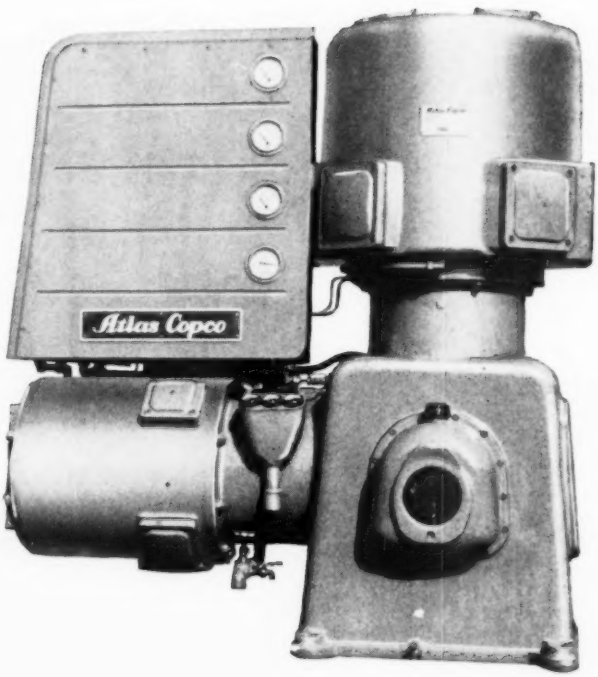
M-W.78

Here's Air Power at
ROCK BOTTOM cost

ER6 Heavy-Duty Compressor for reliable 3-shift operation

Atlas Copco's ER6 compressor delivers air at the lowest possible cost. Designed to incorporate *every* economy factor, it combines the lowest possible running costs with low installation costs and a space saving design.

The ER6 delivers 1,075 cfm at 100 psi (30.4 m^3/min at 7 kg/cm^2) for a power consumption that is absolutely rock bottom. Thanks to a new type of intercooler, water consumption is only 440 imperial gallons (2,000 litres) per hour—a *quarter* the consumption of most similar machines. The ER6 is compact. Occupying only half the space usually required for machines of its capacity, it saves expensive factory space. In addition, installation costs are lower as new, cheaper installation methods are employed.

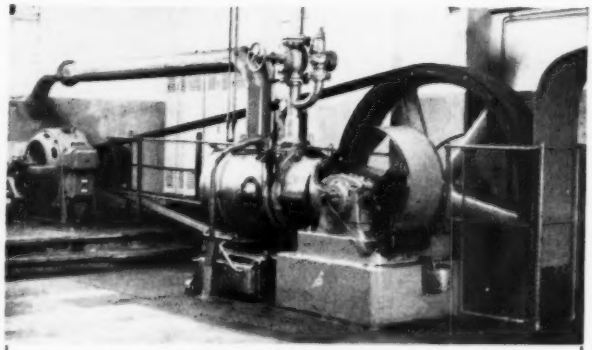


RANGE OF STATIONARIES

From 2.5 to 20,000 cfm, there is an Atlas Copco stationary compressor to suit every requirement. Whatever the design factor—compactness, low installation cost, low operating cost, or a combination of all three—Atlas Copco stationaries are high-performance machines you can rely on.

Sales and Service in Ninety Countries

Represented in ninety countries, Atlas Copco is the world's largest organisation specialising solely in compressed air equipment. Products include stationary and portable compressors, rock drills, loaders, hoists, air tools and paint-spraying equipment. Wherever you are, the international Atlas Copco group offers expert advice and provides a complete after-sales service.



Built to last. This Atlas Copco compressor was installed at the Bofors engineering works (Sweden) in 1907. It is still in operation.

WRITE FOR THE LEAFLET

Leaflet E1127 gives full details of the ER6 compressor. Write for a copy to your local Atlas Copco company or agent or to the address at the foot of this advertisement.

Atlas Copco puts compressed air to work for the world

Atlas Copco AB, Stockholm 1, Sweden. In the U.K. Atlas Copco (Great Britain) Ltd., Hemel Hempstead, Herts.

SC 38

HOLSET NON-BONDED RUBBER CRANKSHAFT DAMPERS

chosen for new B.M.C. Saloons

By courtesy of the British Motor Corporation.

A combined torsional vibration
damper and pulley offers a unit ready balanced
and assembled for immediate
fitting to the engine crankshaft

THE **HOLSET** ENGINEERING CO. LTD.
Turnbridge · Huddersfield

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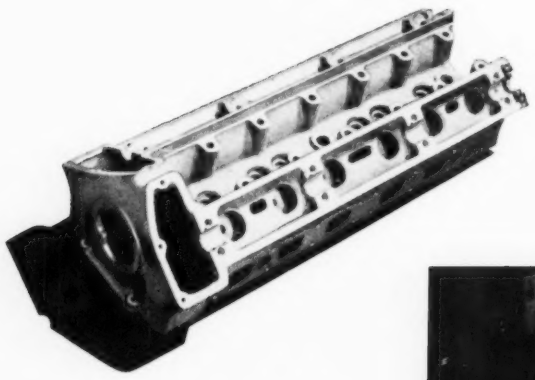
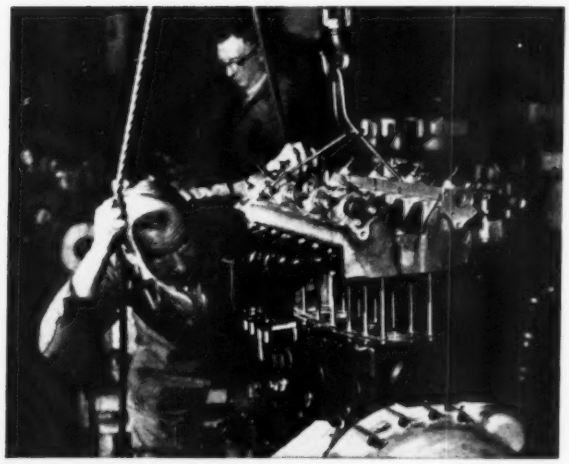
On with her head!



For many years, William Mills have supplied aluminium castings for the cylinder heads, sumps and manifolds of Jaguar cars. The range of Mark 2 models, introduced for 1960, uses similar castings in LM4 alloy, and the intricate cylinder head casting shown is a fine example of modern foundry technique.



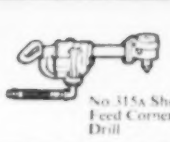
Aluminium alloy castings by

William Mills Limited

WILLIAM MILLS LIMITED, FRIAR PARK FOUNDRY, FRIAR PARK ROAD, WEDNESBURY, STAFFS.
AP132

The right DRILL for the job... ...and CP make it!

HERE ARE 7 DIFFERENT C.P DRILLS



If you are dealing with $\frac{3}{16}$" holes on light construction work, or 3" holes on heavy engineering—CP make the drill you need for the job. For drilling, reaming, tapping or tube expanding—there are CP drills in speeds to suit any operation.

CP, in fact, make the right tool for *every* drilling job. Seven drills from this comprehensive range are illustrated here; you can see the full range to suit all requirements in the CP Drill Catalogue.

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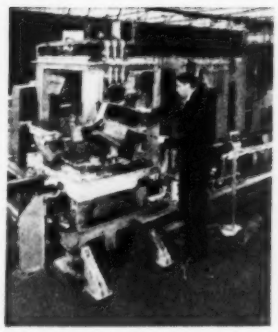
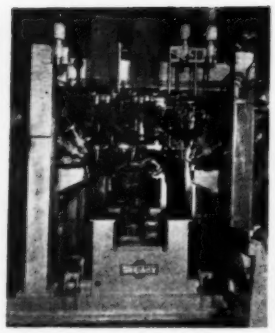
CONSOLIDATED PNEUMATIC TOOL COMPANY LIMITED · DAWES ROAD · LONDON · S.W.6

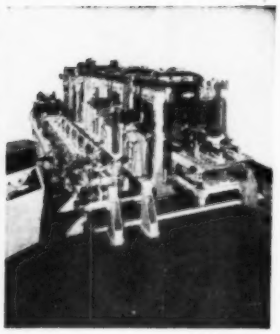
Affiliated and Subsidiary Companies throughout the world

CP/216

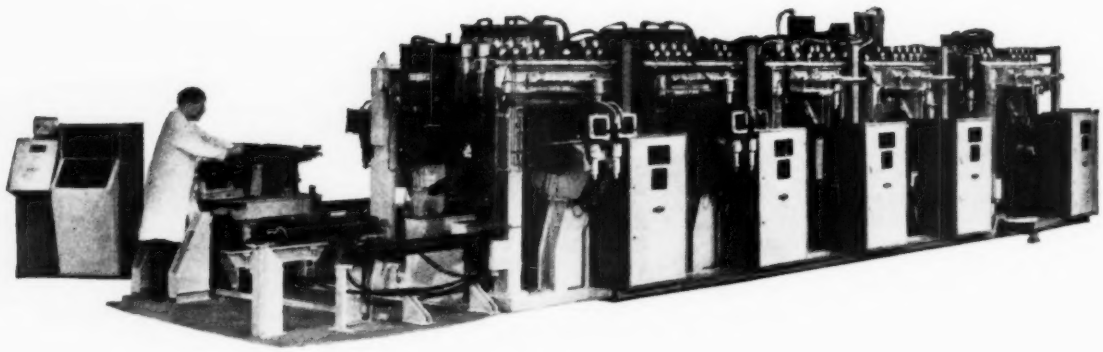
Illustrated is a transfer resistance welding machine, recently designed and constructed by Sciaky. It welds the front suspension and engine mounting units of the BMC mini cars in 5 stages. Welding cycle and transfer between stages is automatic. 3000 units per 40 hour week production.







a welding machine... ...a production line



Every day thousands of Sciaky Resistance Welding Machines are used to produce Britain's automobiles. Working closely with the motor industry, Sciaky has developed a range of welding machines to meet their critical requirements. But, the story does not end there . . . the adaptation of resistance welding to a specific application—the Sciaky technique—is yours for the asking. Let Sciaky experience and know-how work for you, because Sciaky resistance welding techniques are developed to meet your individual needs—whether portable, pedestal, or complete production line.

this is what

SCIAKY

resistance welding means

SCIAKY ELECTRIC WELDING MACHINES LIMITED
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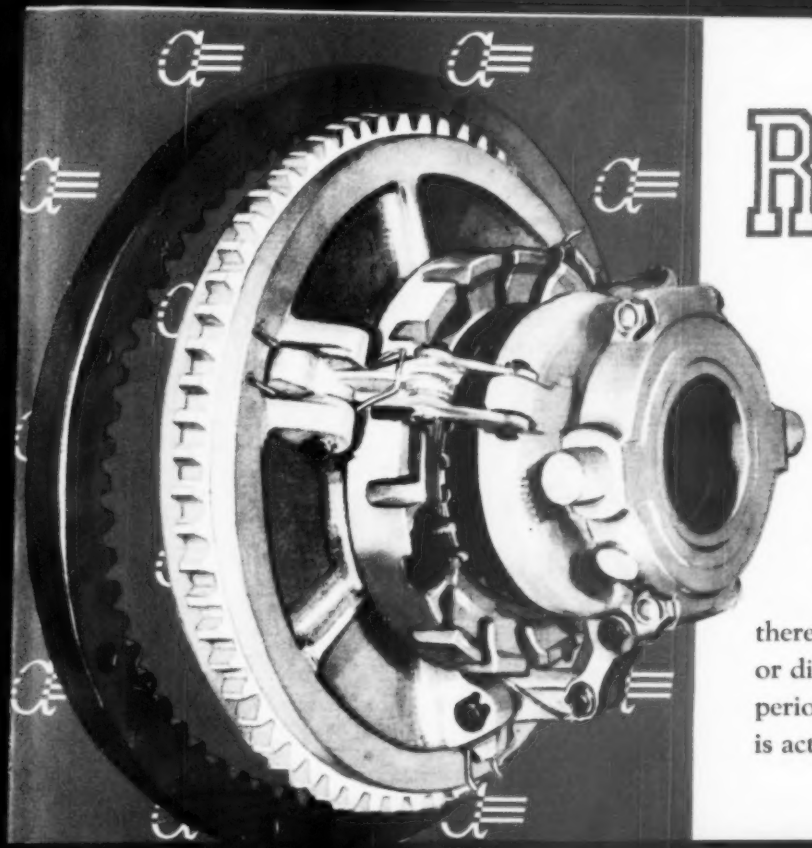

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includes strap-drive clutches in 12″, 13″, 14″ and 15″ sizes, heavy duty 16″ and 18″ lug drive clutches, all being available in single or multi-plate form, and 10″ and 11″ integral clutch and power take-off units.

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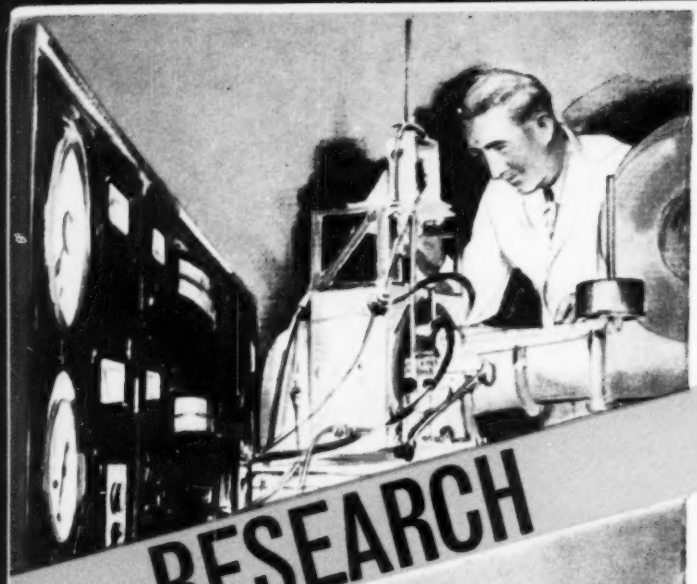
Leamington Spa, Warwickshire, England

BORG & BECK

Specialists in the transmission of power

REGD. TRADE MARK BORG & BECK



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Intensive investigation on special test machines of our own design.

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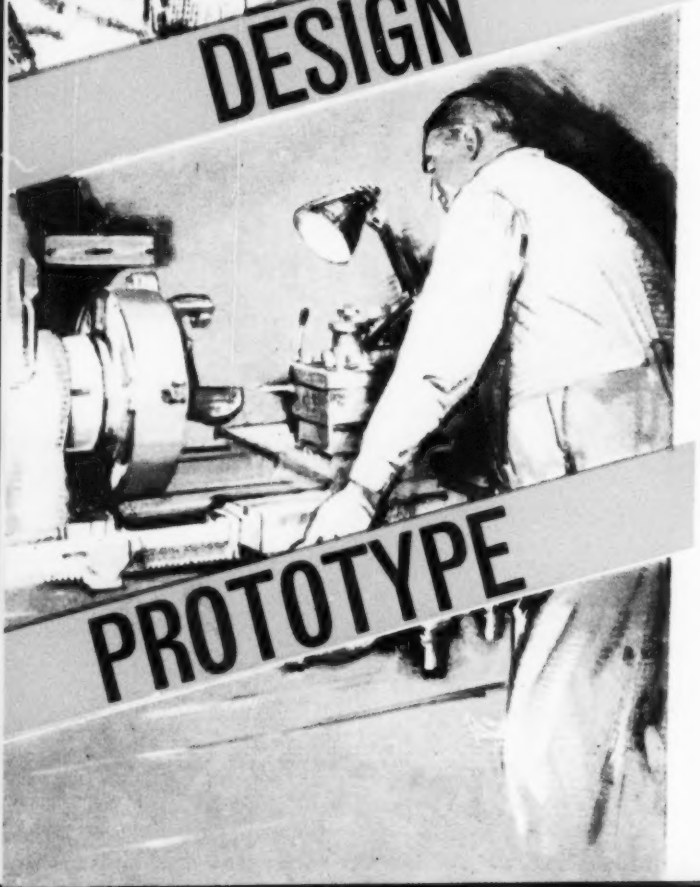
Based on development in 30 years' specialized experience.



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True samples, identical in every way with prospective production design.

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LOCKHEED HYDRAULIC BRAKE COMPANY LTD.

LEAMINGTON SPA
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VEHICLE DESIGN

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PMENTS
THE
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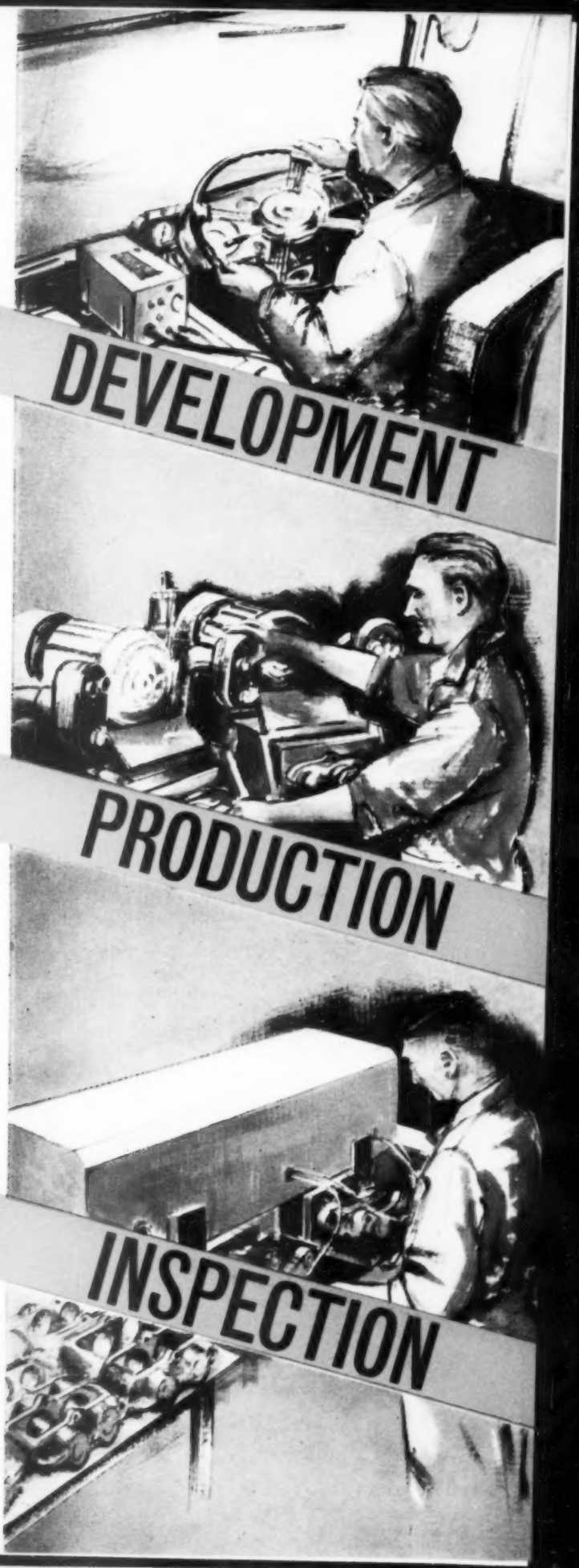
ONE OF THE AUTOMOTIVE PRODUCTS GROUP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By extended road trials and bench tests, using special instruments and techniques.
PRODUCTION
By Britain's finest machine tools, with best materials, to fine tolerances and high finish.
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Rigidly held to procedure established by years of attention to Quality Control in this factory.

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PERFECT SAFETY

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ONE OF THE AUTOMOTIVE PRODUCTS GROUP

AUTOMOTIVE PRODUCTS COMPANY LIMITED
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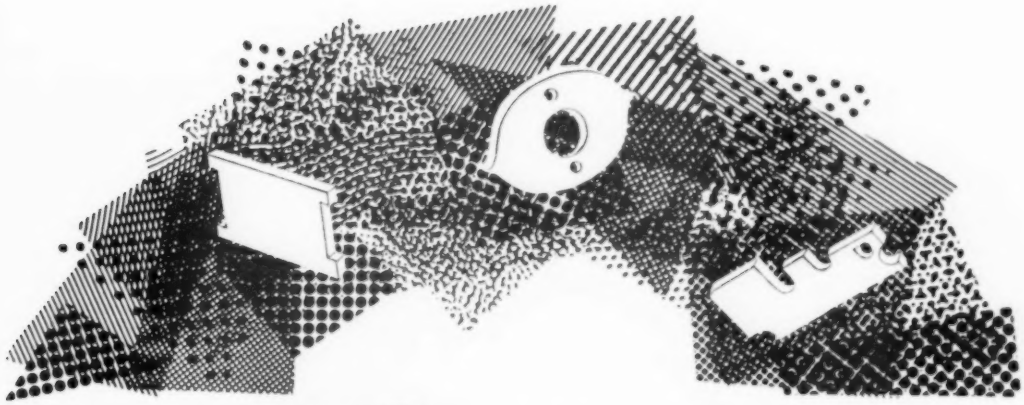
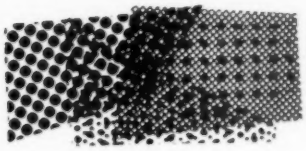
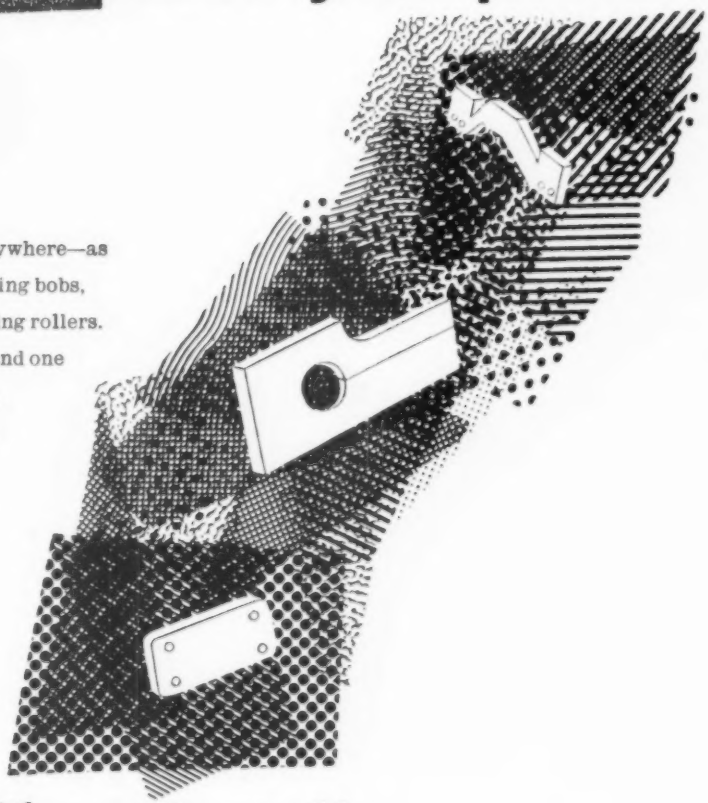


Let BURY FELT solve your problem





You'll find Bury Felt everywhere—as washers, seals and gaskets, polishing bobs, anti-vibration bases and buffing rollers. These are only a few of its hundred and one uses. You will think of many more. For Bury Felt is what you make of it; it can be chiselled, punched, machined or die-cut to suit your needs and is available in many types and textures.

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64

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for internal and external superfinishing
This illustration shows external superfinishing on Gudgeon Pins in the Patricroft works of L. Gardner & Sons Limited, the well-known oil engine builders. Two further machines are employed in the same factory for high precision bore finishing on cylinder blocks.
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IF 250

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Automate the Production of Gears

Drummond Automatic Multi-Tool Lathes, Gear Shaping Machines and Gear Hobbing Machines can be supplied as linked lines for completely automatic rough and finish turning gear shaping and gear hobbing.

A typical arrangement of machines is shown in the diagram below, as exhibited at Olympia for the production of a cluster gear.

The first machine in the line, the "Maxirapid," rough turns the component, the "Maximinor" then turns all gear diameters and various chamfers. The No. 2A "Maxicut" Gear Shaper is the next machine in the line and cuts a 27 tooth helical gear; finally the 12 in. "Hoblique" Automatic Gear Hobber cuts a 43 tooth helical gear.

This arrangement demonstrates the high production possibilities of Drummond Machines for link line gear production.

DRUMMOND BROS. LTD.

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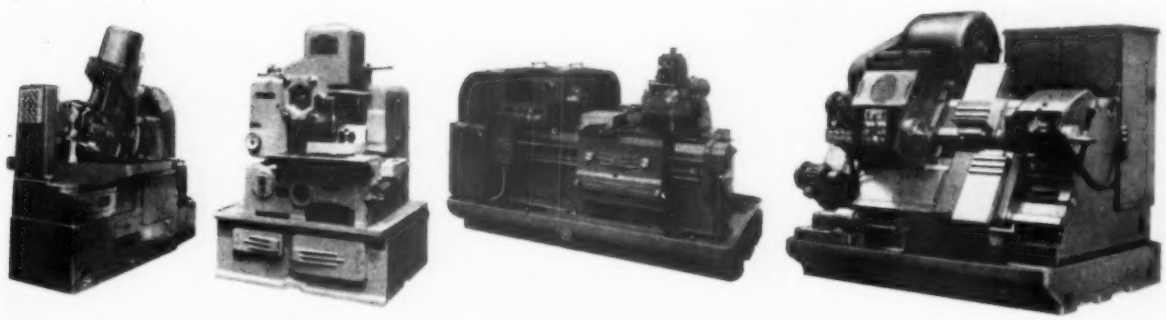

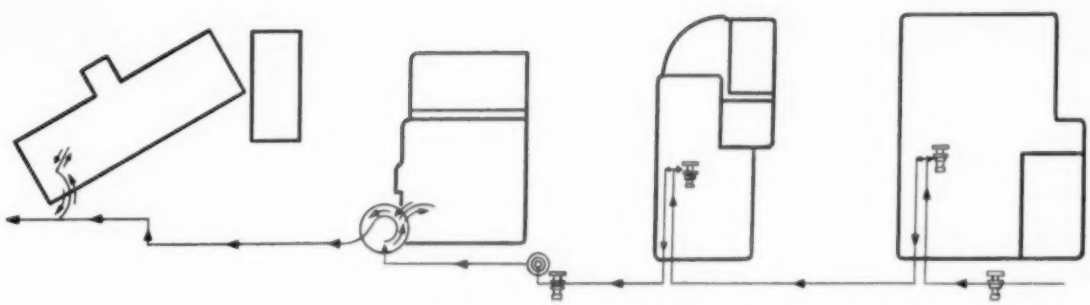

12" "Hoblique" Gear Hobber. "Maxicut" 2A Gear Shaper. "Maximinor" Multi-Tool Lathe. "Maxirapid" Multi-Tool Lathe.

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"ARO-BROOMWADE" PAR-A-MATICS

— are self-feed pneumatic tools which can be mounted at any angle for automatic or semi-automatic operation *on long or short production runs.*
One man can operate a whole battery of Par-A-Matics and any number can be linked for simultaneous operation.

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CONVOLUTED HOSE

Stockinette re-inforced or plain, John Bull convoluted hoses are made in natural or synthetic rubber to withstand high and low temperatures, oil and chemical attack and ageing. They are suitable for gases as well as liquids. Manufactured by the patented John Bull process, uniformity of wall thickness is retained throughout the convolutions. Air cleaner hoses are made to the same high standard.

All rubber hose is available in standard 45 ft. lengths in a range of diameters. Specially reinforced hose can be manufactured to your requirements.

In addition to Convoluted Hose, John Bull produce Radiator Boots and Gaiters, Shaped Hoses and Rubber Mouldings.

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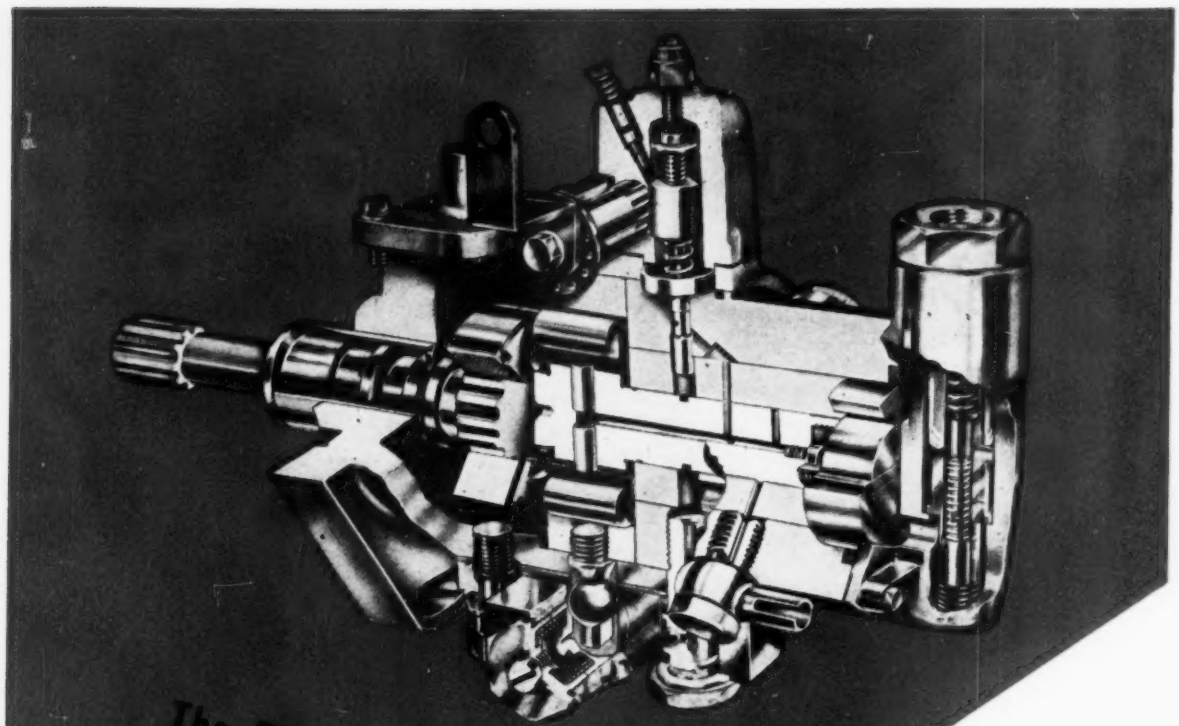
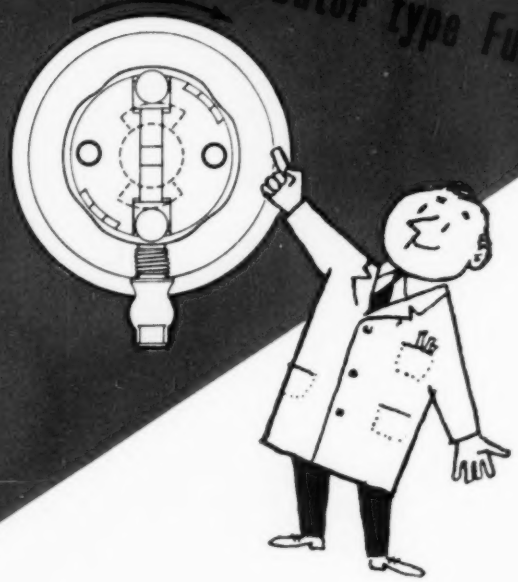


The Distributor type Fuel Injection Pump



ONE PUMPING ELEMENT ONLY

The DPA pump is basically simple in design, and has one pumping element only. This delivers fuel to each cylinder in turn, through the distributor. Accuracy of delivery is 'built in' by high precision machining. No phasing or calibration is required. There are no highly stressed springs—the opposed plungers are returned by oil pressure. The complete unit operates in filtered fuel oil, and wear is negligible. The DPA is ideally suited for high speed diesels—already over a third of a million are in use throughout the world.

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The World's Largest Manufacturers of

FUEL INJECTION EQUIPMENT

C.A.V. LIMITED, ACTON, LONDON, W.3.

AP 964

Interchangeable, on the same mounting, with the standard Marles manual gear unit.

MARLES type 4 'Universal' power-steering gear

This latest type 4 unit embodies the wide experience of Marles in power-steering, and consists of a 2-valve box mounted on the top of the standard Marles 861 manual gear unit.

The type 4 Universal unit shown above, the type 3 Universal unit and the standard manual unit are all interchangeable on the same mountings.

Further particulars will be sent on request.

ADAMANT ENGINEERING CO. LTD.,
THE AERODROME, WOODLEY, Near READING.

Sole proprietors of the Marles Steering Company Ltd.

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FULL-GRIP NON-SLIP P

-the first major development in belt drives in 60 years!

- **Greater power transmission ▪ Less power loss**
- **Cooler running–with minimum wear and abrasion and maximum life**
- **Economy in space, weight, and replacement costs**

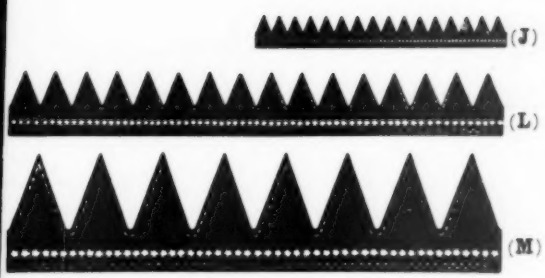
POLY-V belts are an entirely new concept in transmission drive . . .

POLY-V* belt's multiple 'teeth' grip pulleys throughout the entire friction surface—a surface twice the area of conventional multi-drives, one third more than conventional single drives.

Power wastage, slip and abrasion are reduced to minimal proportions. Because of the higher ratios made possible, transmission systems can be simplified and reduced to minimum size, weight and cost. A far more compact drive unit can be achieved and the shallow grooves permit easier fitting and replacement.

POLY-V belts are made from synthetic rubber compounds (having the heat-and-oil-resistant properties of today's "Premium" V-Belts). Strength is given by high-tenacity synthetic cords. The base rubber is 'soft' compared with orthodox 'V' Belts—its action resembling a hydraulic fluid and forcing the 'teeth' into perfect mating with the pulley grooves, with even overall pressure.

)LY-V BELTS NOW available in Britain!



THERE ARE THREE BASIC RIB SIZES OF POLY-V BELT

Section	Rib Width	Rib Quantities	
		Minimum	Maximum
J	$\frac{3}{32}$ in.	2	16
L	$\frac{3}{16}$ in.	6	20
M	$\frac{3}{8}$ in.	4	20

V angle is 40° in each case.

SPECIAL APPLICATION OF "POLY-V" BELTS FOR THE AUTOMOTIVE INDUSTRY

The advantages of POLY-V belts have been amply proved in America—where they are now extensively used throughout industry.

In the design of engines for heavy public service and commercial vehicles, POLY-V drives can replace the multiple systems used for fan, water pump and generator drives with a *single belt and pulley system*—and transmit the same horsepower from narrower pulleys eliminating the necessity to find matched belt sets.

POLY-V belts can give neater, more efficient drives for air-conditioning units, supercharger and tachometer drives and pump units on power steering equipment. Further usage may be for dynamo drive in motorcycles—perhaps even as a direct drive for mopeds and lightweight motorcycles.

POLY-V
TRADE MARK

BELTS ARE MARKETED TO THE AUTOMOTIVE INDUSTRY BY

FERODO LIMITED

Designers and engineers are invited to write for further technical information from:

FERODO LIMITED · CHAPEL-EN-LE-FRITH · DERBYSHIRE *A Member of the Turner & Newall Organisation*

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STOP OZONE ATTACK

WITH DU PONT ELASTOMERS

Ozone is present in the atmosphere, generated from Oxygen in the air by ultraviolet light (from sunlight). When natural rubber is stressed, as in car components, ozone attacks, forming a myriad of small cracks in the surface of the rubber.

DU PONT NEOPRENE has outstanding resistance to ozone cracking. Du Pont neoprene has proved under test, and on the job, that it is vastly superior to natural rubber—and to "general purpose" synthetics. Neoprene resists oil and grease in the chassis . . . high temperatures under the bonnet . . . oxidization and aging of exposed parts and accessories. Properly compounded neoprene products meet most service needs at temperatures ranging from —54°C to as high as 121°C. Compounds can be made soft or hard and in sponge form. HYPALON* synthetic rubber has even greater heat and ozone resistance and is known for its remarkable colour stability, permitting use of bright colours for weather stripping and convertible tops. Hypalon doesn't become brittle in cold weather nor will it crack under heat or summer sun.

*HYPALON IS DU PONT'S REGISTERED TRADEMARK FOR ONE OF ITS ELASTOMERS

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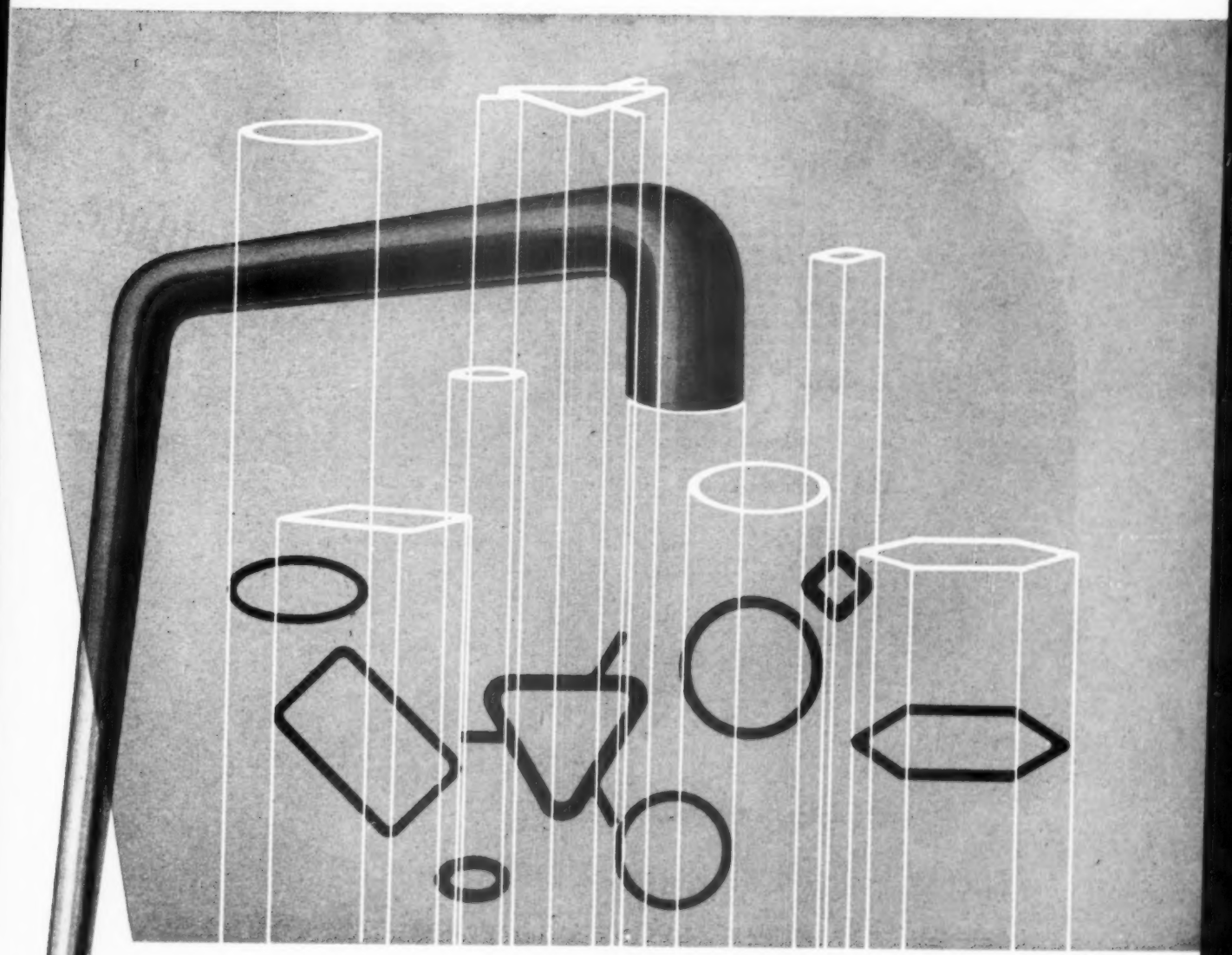
NEOPRENE-HYPALON*

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

Automobile Engineer 8/60 (21 765 01)

Is manipulation critical?



H.D.A. tubes can keep their temper...

Loss of temper in tubes, and of tempers in boardrooms, have both become rarer since H.D.A. evolved Hiduminium 1C, 14, 22, 43 and 46—alloys specially developed by them for easy manipulation. Drawn tubes and hollow extruded sections made from these alloys are not only easy to manipulate: they retain their strength and smooth surface finish, as well as their weldability and excellent resistance to corrosion. Manipulation is only one of the problems associated with tube and hollow sections; but H.D.A. have all the technical knowledge and skill that the subject calls for—freely available on request.

Hiduminium

makes the most of

Aluminium

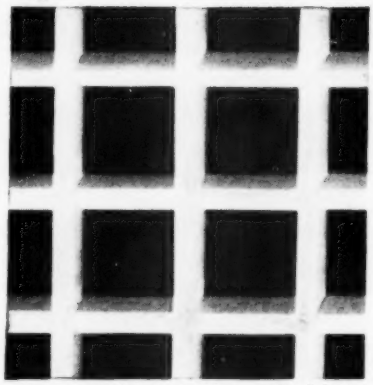
HIGH DUTY ALLOYS LTD · SLOUGH · BUCKS

for heat resistance

special "thin-flash" type for grille moulding

Beetle D.M.C. is the material used for the grille of the Morphy-Richards Fan Heater because it offers high heat resistance and good appearance. The use of D.M.C. posed a flash-removal problem in relation to the many apertures, as the moulders, Crystalate (Mouldings) Ltd., specified a very thin flash line. Accordingly, B.I.P. Chemicals Ltd. developed a special type of material (D.M.C. L.1834) which, in combination with a tool made to close limits, ensures a consistently thin and easily removed flash.

Beetle D.M.C. combines heat resistance with strength, dimensional stability and excellent insulation properties. The development of a special type for a single application typifies the extent of B.I.P. services in relation to individual problems and requirements.



Heat resistance, dimensional stability, strength and electrical insulation properties are among the features making D.M.C. the ideal material for this grille. Moulding by Crystalate (Mouldings) Ltd., Tunbridge, Kent.

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Polyester dough moulding compound

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— assembled to customers' drilling requirements

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This equipment meets all general-purpose single or multi-spindle requirements. Unit construction and interchangeability enable special requirements to be easily met.

We will quote for machines and equipment to meet special requirements for drilling, tapping and associated operations.

Three Type M Multi-spindle top columns on a common base for drilling seven ·328" dia. holes and drilling and tapping five ¼" dia. 26 t.p.i. holes in a gearbox inner cover. Cover located in traversing fixture. Floor-to-floor time is 3 minutes.

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Success

International

Since 1951 Jaguar cars have used Salisbury differential units exclusively. In this period they have won over 80 major International races and rallies as well as hundreds of minor successes. In all these competition events not one Salisbury differential has ever failed. Every one has been standard design as used in production cars.

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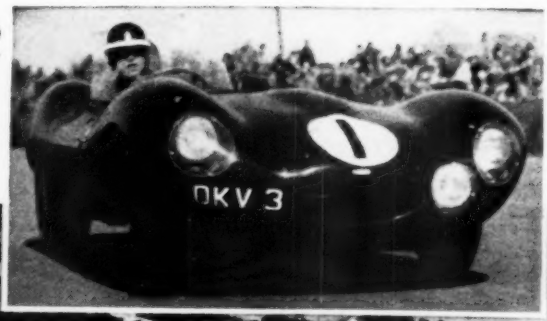
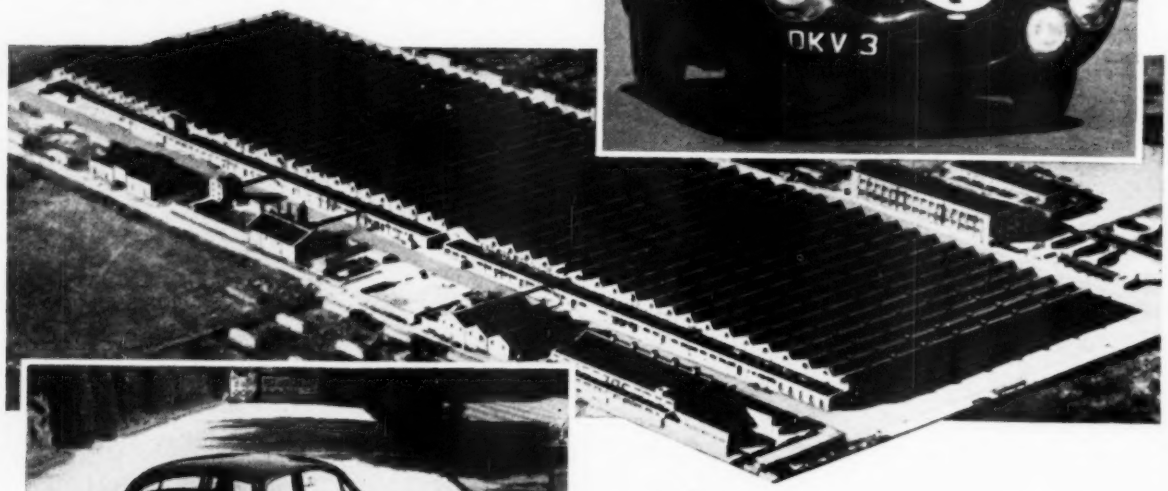
PETROL AGENCY DERV **THIS IS THE SIGN THEY SHOULD LOOK FOR.**

BP DIESEL

Mike Hawthorn (D Type Jaguar) at Silverstone.



The Growth of an Enterprise



The Jaguar Mark 2 Saloon.

"The West Midlands Gas Board kept their target with this new main to an extent which could not have been bettered by any other commercial organisation!"

The roots of the Jaguar organisation extend back for 38 years, when the present Chairman and Managing Director, Sir William Lyons, then Mr. Lyons, in company with a partner, started a modest factory for the manufacture of Swallow sidecars at Blackpool in 1922. By 1928 the Swallow Company had outgrown two factories and in that year moved to a large factory in Coventry. It was from that factory in 1931 that the first complete car made by the Company to have an identity of its own emerged under the name S.S. (Swallow Sports). In 1933 a new company was formed—S.S. Cars Ltd.—the original Swallow concern remaining in being, and in 1935 the first Jaguar saloon was introduced. Two-seater sports cars were added to the range—the Company being the first to produce a 100 m.p.h. regular series production car at a price of under £450.

The War, of course, called a halt to the progress of all motor car manufacture and in 1945 the newly named Company—Jaguar Cars Ltd.—set out with the primary object of raising the prestige of the British Car Industry abroad. It did this by combining exceptional technical design and high performance with near-perfect finish. In the years following the War, official Jaguar teams and private owners have won over 80 major international races and rallies and acquired hundreds of successes in the lesser national and international events. The fact that the Jaguar name has been blazoned across the World is confirmed by the fact that in the post-war years 56.9% of Jaguars went abroad, and no less than 48.2% captured the American market.

The total number of workpeople employed in the Jaguar factory is now 4½ thousand and the Company occupies a 78-acre site in Coventry. Open competition successes have placed the efficiency of the power and transmission systems of the Jaguar beyond reproach, but for the average motorist a high standard of finish which combines excellence in appearance with almost complete resistance to corrosion is just as important. The visitor to the factory cannot help but be impressed with the care taken on the finishing lines. A newly installed plant takes the car body on a huge spit through water rinsing, cleaning, phosphating and a chromic acid rinse. After drying, the body is dipped in a slipper paint bath to protect the innumerable nooks and crannies underneath, and then the surfacer coats are applied. Thus every car is adequately protected from corrosion. The protected bodies now pass on over-head conveyors through the remainder of the plant. The first operation is to spray sound deadener and sealing composition on the under side and then come rubbing down, the application of the sealing coat, and the final colour coats. During the whole of this time the car body remains on its mobile spit.

The complete sequence of finishing operations is as follows:—

1. Remove any oil from body.
2. Metal preparation and fittings.
3. Apply catalyst filler to holes in the lead loaded areas.
4. Transfer body to overhead dual conveyor.
5. Clean and phosphate body in 6-station spray phosphating plant, using low temperature process.
6. Dry in dry-off oven—temperature 320 F.
7. Apply synthetic stopping as required
8. Tac rag.
9. Slipper dip lower half of body.
10. Drain and flash off.
11. Spray primer surfacer single and double header coats using Ecco 30 spray gun.
12. Stove for 45 minutes at 275/280 F.

13. Unload body from conveyor on to mobile spit.
14. Spray bituminous compound for sealing and sound deadening on the underside of the car and in the engine compartment.
15. Remove sound deadener overspray.
16. Wet wipe—320 paper.
17. Spin body to remove surplus water—dry off in oven at 265 F.
18. Spray one double header coat of sealer using Ecco No. 30 spray gun.
19. Bake sealer coat 30 minutes—270/286 F.
20. Wet face sealer coat with 400 paper. Spin body to remove surplus water and sponge down.
21. Dry off in oven ten minutes at 225/230 F.
22. Vacuum clean trestle.
23. Tac rag interior surfaces and exterior.
24. Spray door shuts, engine compartment and boot interior in colour.
25. Remove overspray from exterior, solvent wipe and tac rag exterior of body complete.
26. Spray one single and one double header coat of colour.
27. Bake colour coat 45 minutes at 250/265 F.

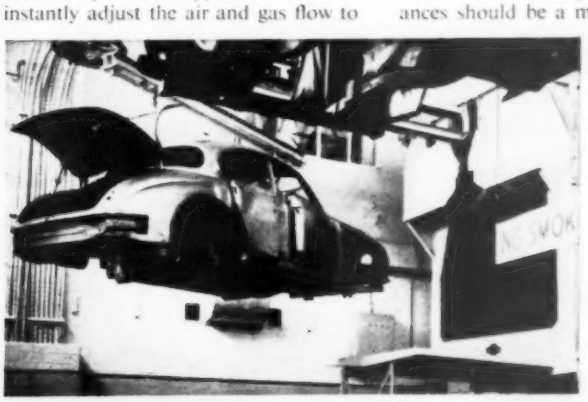
Throughout these sequences the drying and stoving time schedules are vitally important. The gas-fired ovens used in operations 6, 12, 17, 19, 21 and 27 are held under a strict automatic temperature control by control pyrometers which instantly adjust the air and gas flow to ensure that the correct temperature is maintained.

The Final Line

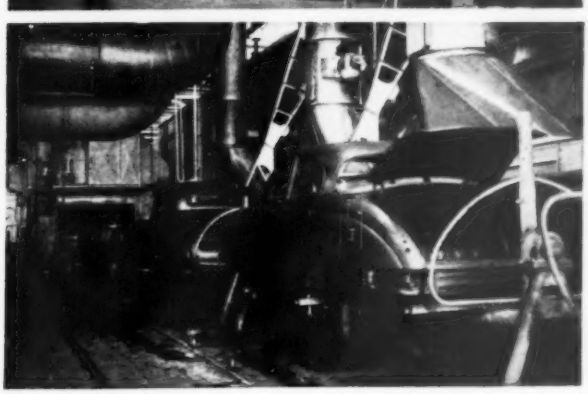
Town gas is also employed in other parts of the plant for numerous heat treatment purposes including annealing and carburizing. These heat treatment operations are, of course, also vitally important to the ultimate performance of the gearing and transmission. The correct time/temperature schedules to introduce the necessary metallurgical structure in the metals are also achieved by control pyrometers in the furnaces, regulating the air and gas supply according to requirements.

When the recent extension of the Jaguar factory was completed it was a formidable task of re-organisation, because it was essential that production disturbances should be a minimum. Such was the increased demand for town gas that the West Midlands Gas Board had to lay on a new high pressure gas main. Executives of the West Midlands Gas Board and Jaguar Cars collaborated closely to maintain the target they had set themselves, and those at Jaguars' commented, "*The West Midlands Gas Board kept their target with this new main to an extent which could not have been bettered by any other commercial organisation!*"

Motor car manufacture is, of course, but one of the thousands of trades, professions and occupations which employ town gas in those production techniques where an automatic heat service is a paramount necessity. Each of the twelve Area Gas Boards throughout the country employs specialised industrial gas engineers, who have studied the many varied techniques of industrial gas application. Industrial gas executives from each of the Area Gas Boards meet regularly to inter-change experiences and discuss new problems which have been presented to them. The result is that any industrialist making an approach to any Industrial Officer at any Area Gas Board has presented to him immediately an overall picture of the latest techniques of heat control, based upon progress made throughout the country—and in addition, the Industrial Gas Information Bureau keeps in close touch with developments in industrial gas usage throughout the World.



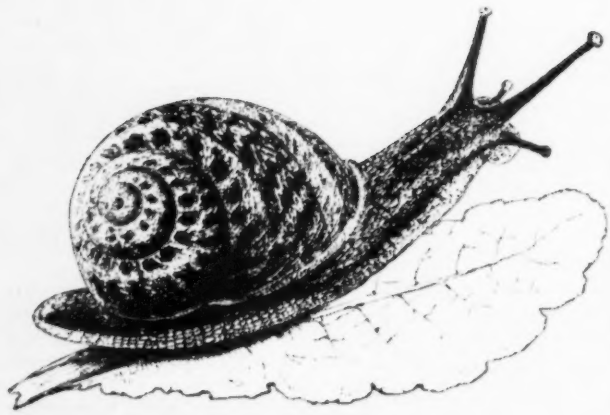
Rustproofing of the Body



The Paint Shop

Scottish Gas Board, Edinburgh
Northern Gas Board, Newcastle-upon-Tyne
North Western Gas Board, Manchester
North Eastern Gas Board, Leeds
East Midlands Gas Board, Leicester
West Midlands Gas Board, Birmingham
Wales Gas Board, Cardiff
Eastern Gas Board, Watford
North Thames Gas Board, W.8
South Eastern Gas Board, Croydon
Southern Gas Board, Southampton
South Western Gas Board, Bath

The Gas Council, 1 Grosvenor Place, London, S.W.1



MADE TO MEASURE

The snail, most thoughtfully, goes to some pains to reconcile his own needs with those of the conchologist • As home and protection, his shell must be tough, portable, and very much made to measure. At the same time, it must have just those qualities which—in due course—will delight the collector • Sheet steel from the City of Steel follows no less closely its intended purpose • Each order is treated as a separate assignment so that you, the manufacturer, get the particular kind of steel your product needs • Steel, in fact, made to measure—to your exact requirements.

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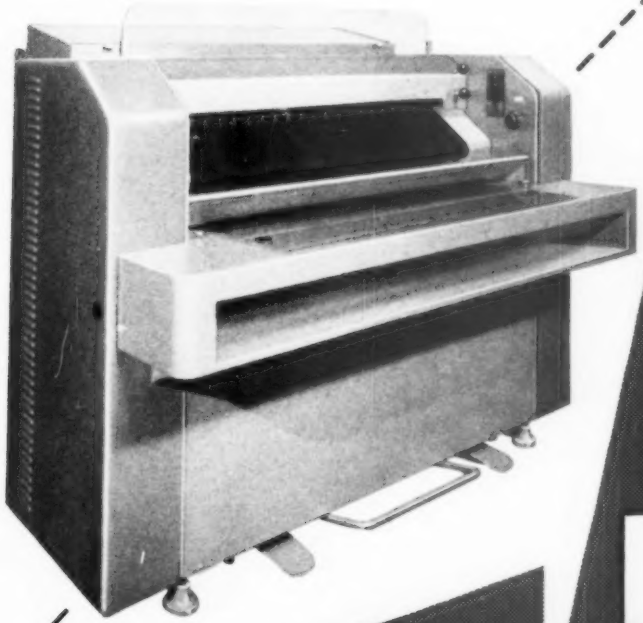

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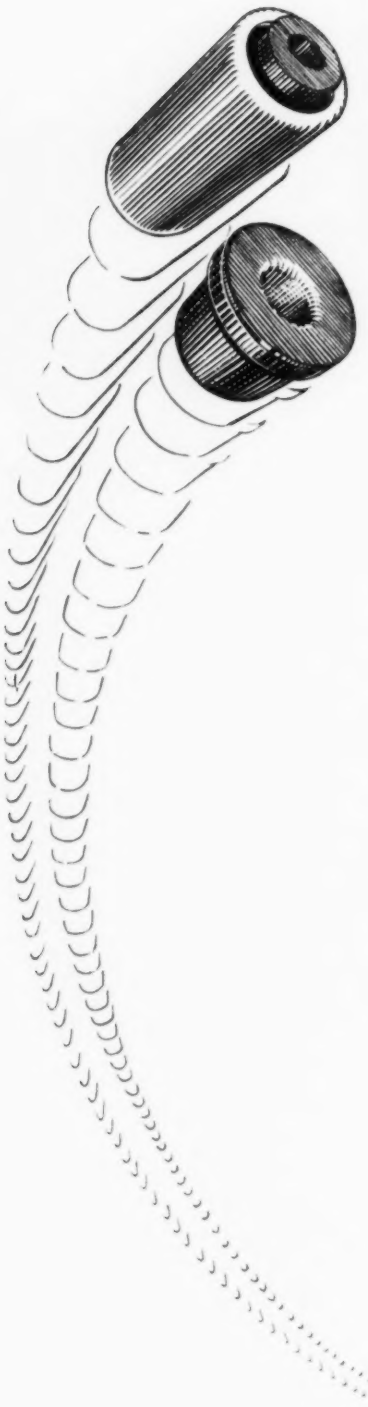
DAY BY DAY



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FLEXIBLE BEARINGS SERVE INDUSTRY

The ever increasing popularity of Clayflex and Harrisflex bearings can only be traced to the confidence Automobile Engineers place in these well proved units.

The pressure and chemically bonded Clayflex bearings are supplied in forms to suit both standard and specialized applications. Outstanding in this range is the BP type bearing which has been specifically designed to give positive axial control under high radial loadings and particularly to cater for high conical deflections which modern design tends to introduce.

Harrisflex controlled flexible bearings are being used for an ever increasing range of applications with new motor vehicles where either space or weight restrictions are involved. In addition these units offer advantages in their ease of assembly on production lines.

For further information concerning these products please ask for the appropriate technical literature.

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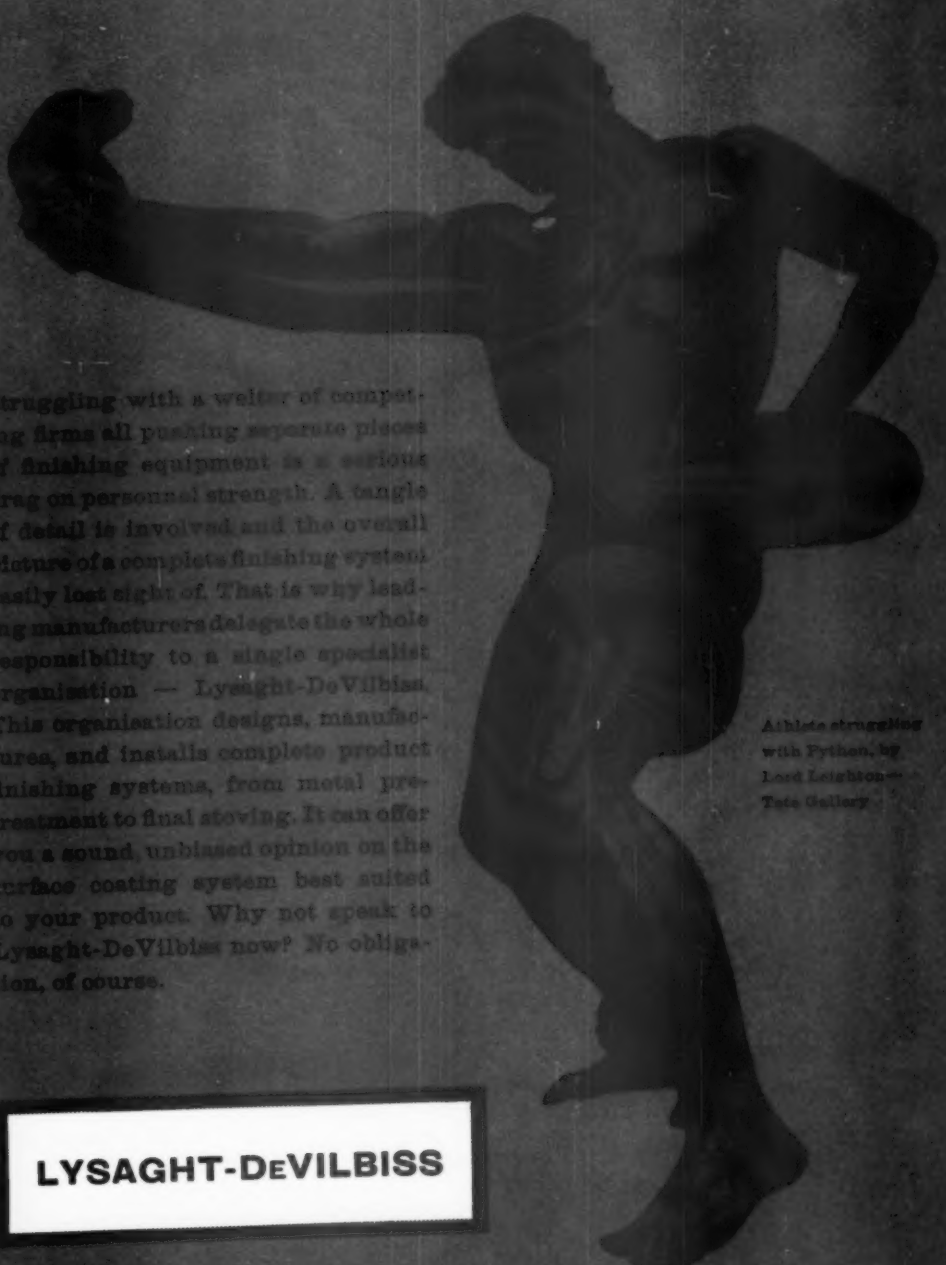

Athlete struggling with Python, by Lord Leighton—Tate Gallery

Struggling with a welter of competing firms all pushing separate pieces of finishing equipment is a serious drag on personnel strength. A tangle of detail is involved and the overall picture of a complete finishing system easily lost sight of. That is why leading manufacturers delegate the whole responsibility to a single specialist organisation — Lysaght-DeVilbiss. This organisation designs, manufactures, and installs complete product finishing systems, from metal pretreatment to final stoving. It can offer you a sound, unbiased opinion on the surface coating system best suited to your product. Why not speak to Lysaght-DeVilbiss now? No obligation, of course.

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Broadway SO2

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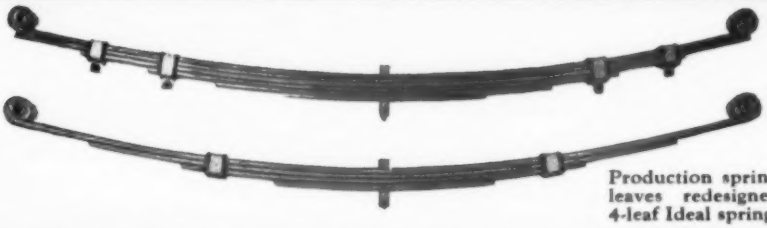
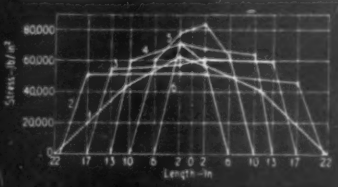
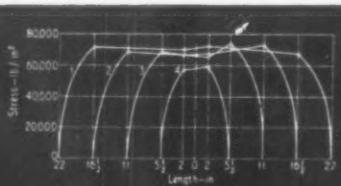
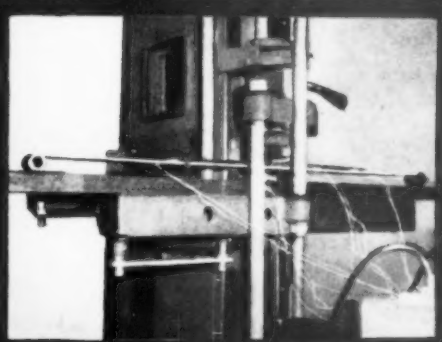


Production spring with 6 leaves redesigned as a 4-leaf Ideal spring.





15-leaf commercial vehicle spring redesigned as 12-leaf Featherlight equivalent without increase in maximum stress.



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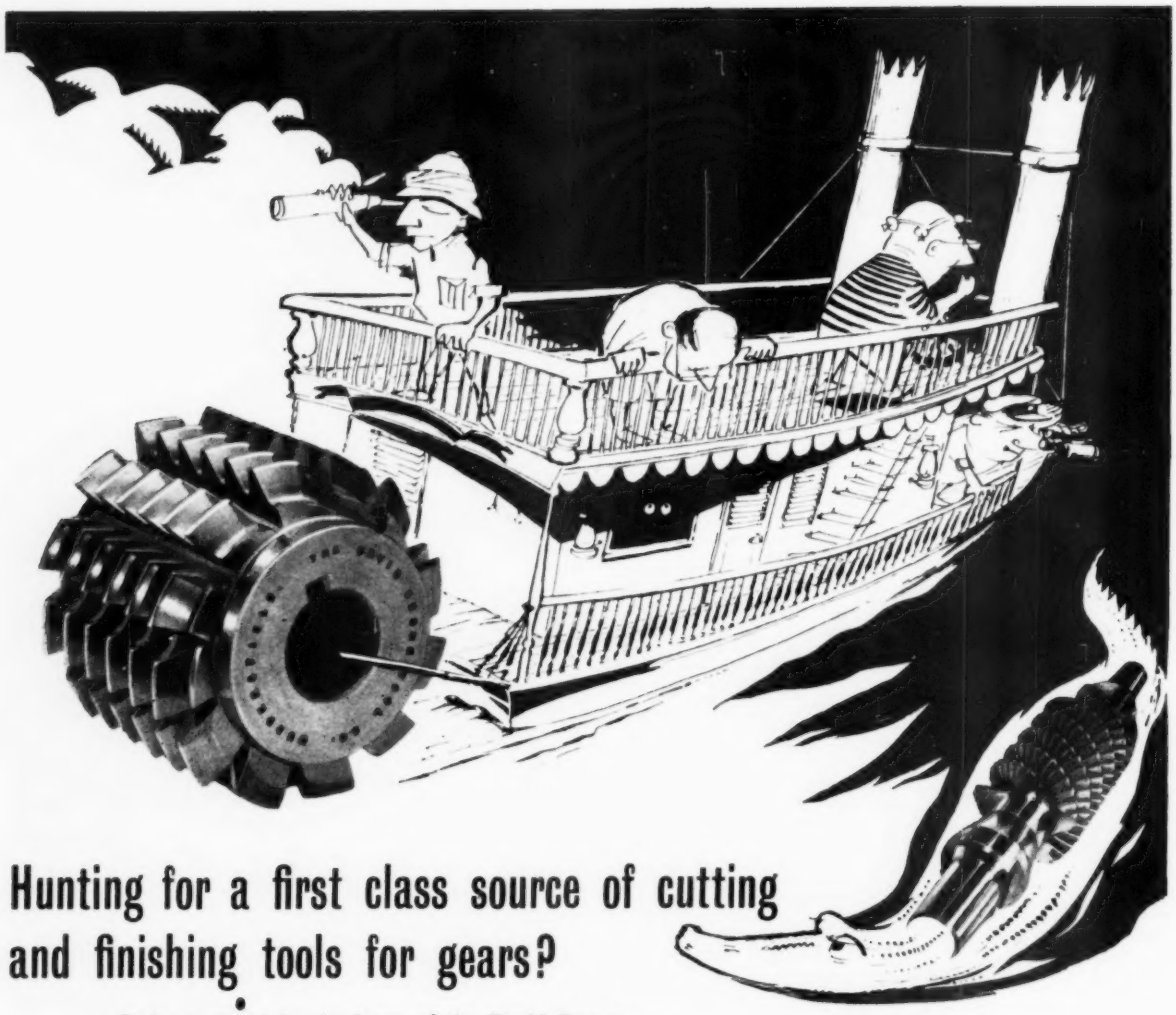

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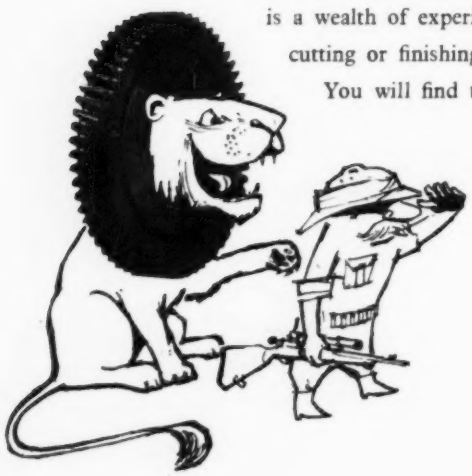

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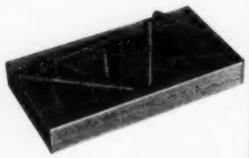

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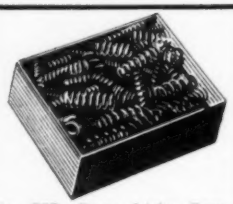

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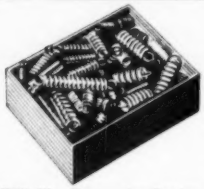

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We can only show a *few* boxes.
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If ever you are stuck with a spring problem let our Research Department put their long experience at your disposal.

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HT80

Alas, I am undone!

Madam—replied our well-known villain—*you* are not the only one. Several thousand plastic bottle stoppers have become undone through my undoing. Little do you know that I make a tiny pneumatic tool with a special adaptor for unscrewing stoppers after moulding. Well, me proud beauty, and what do you say to that?

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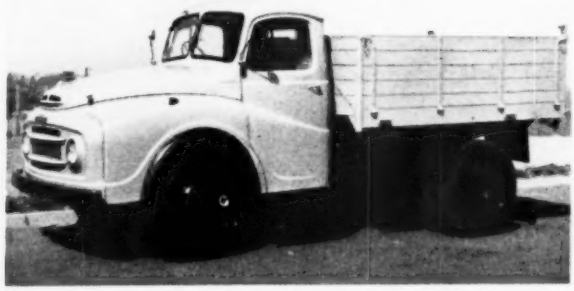

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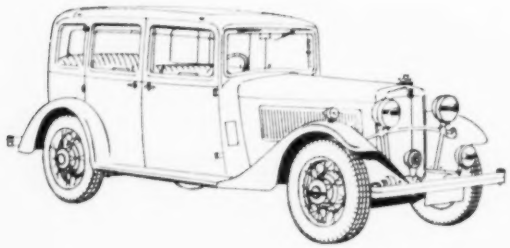

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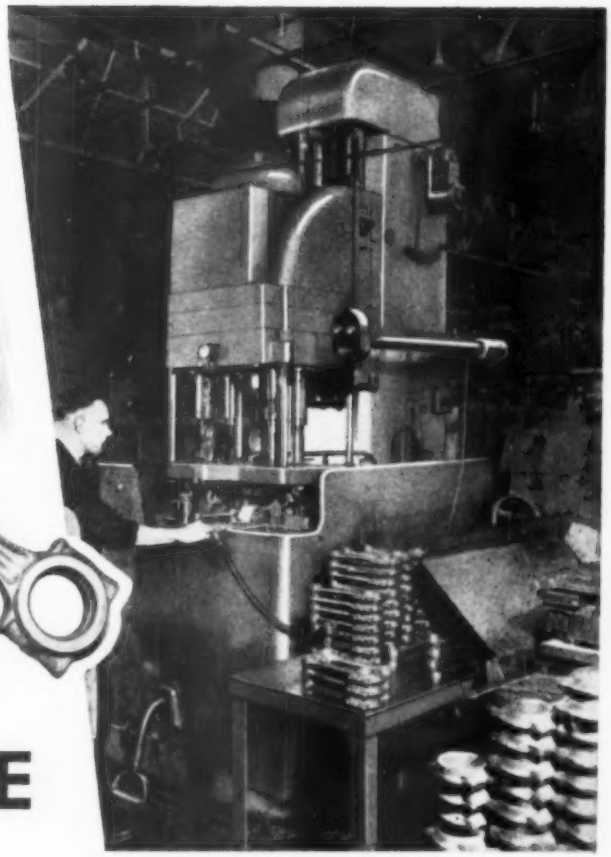

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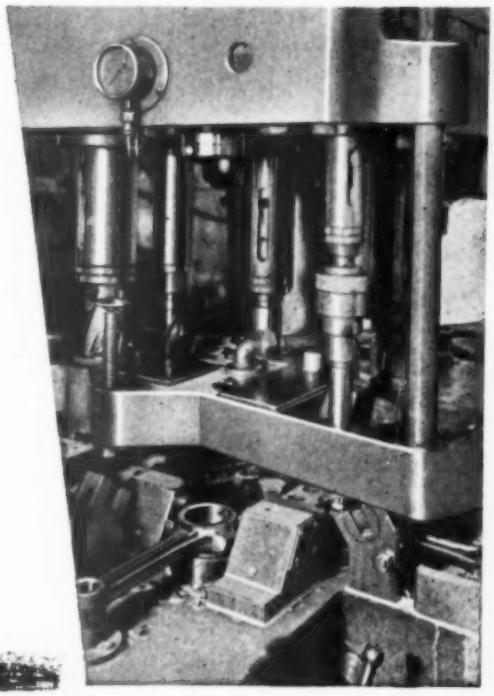

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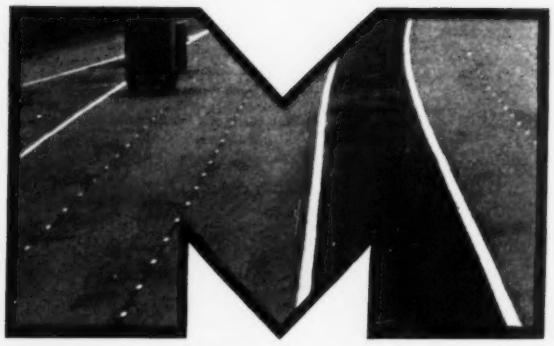

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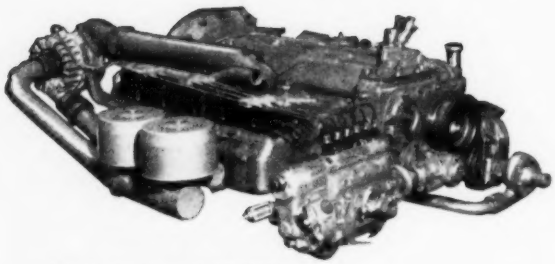

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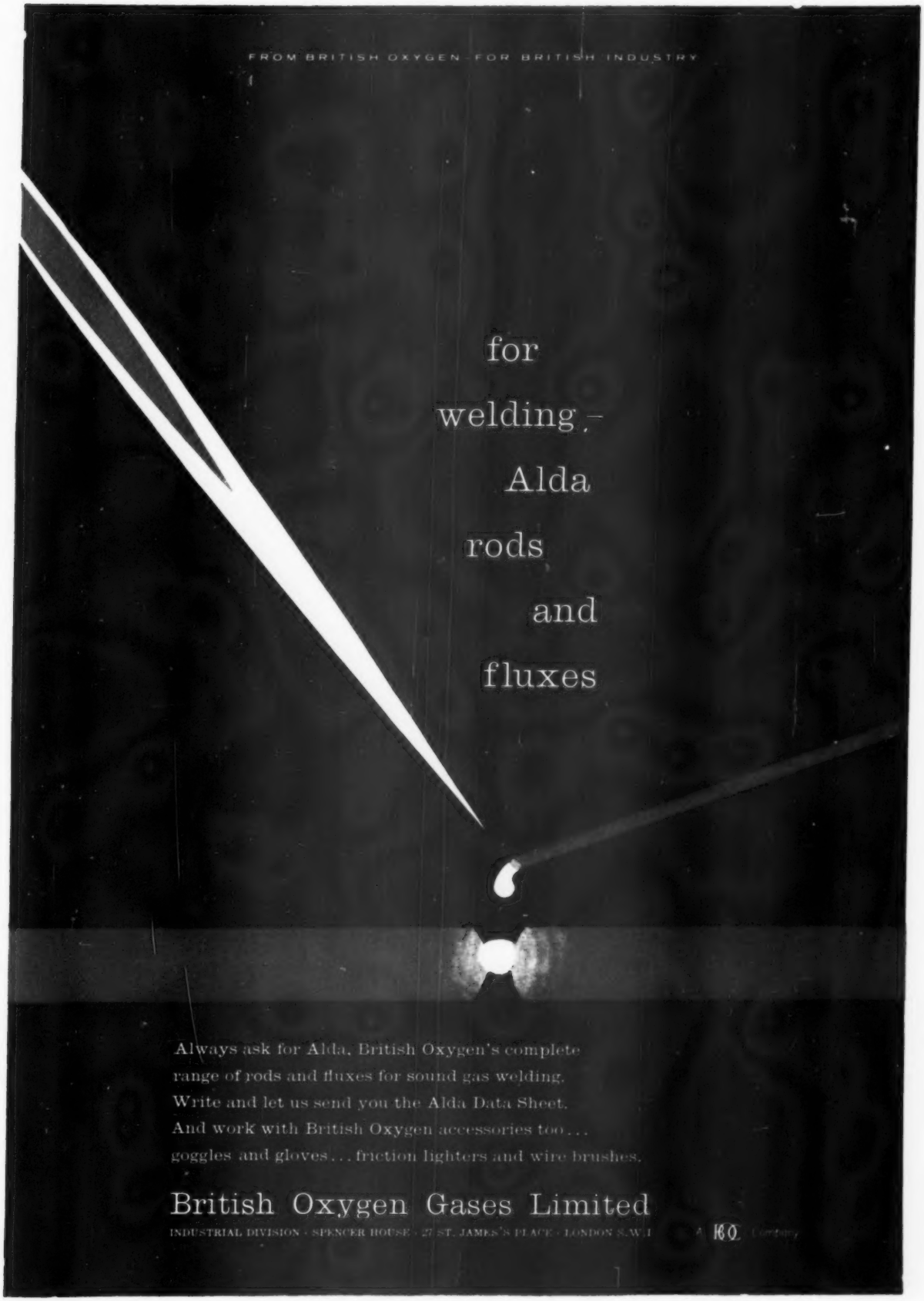
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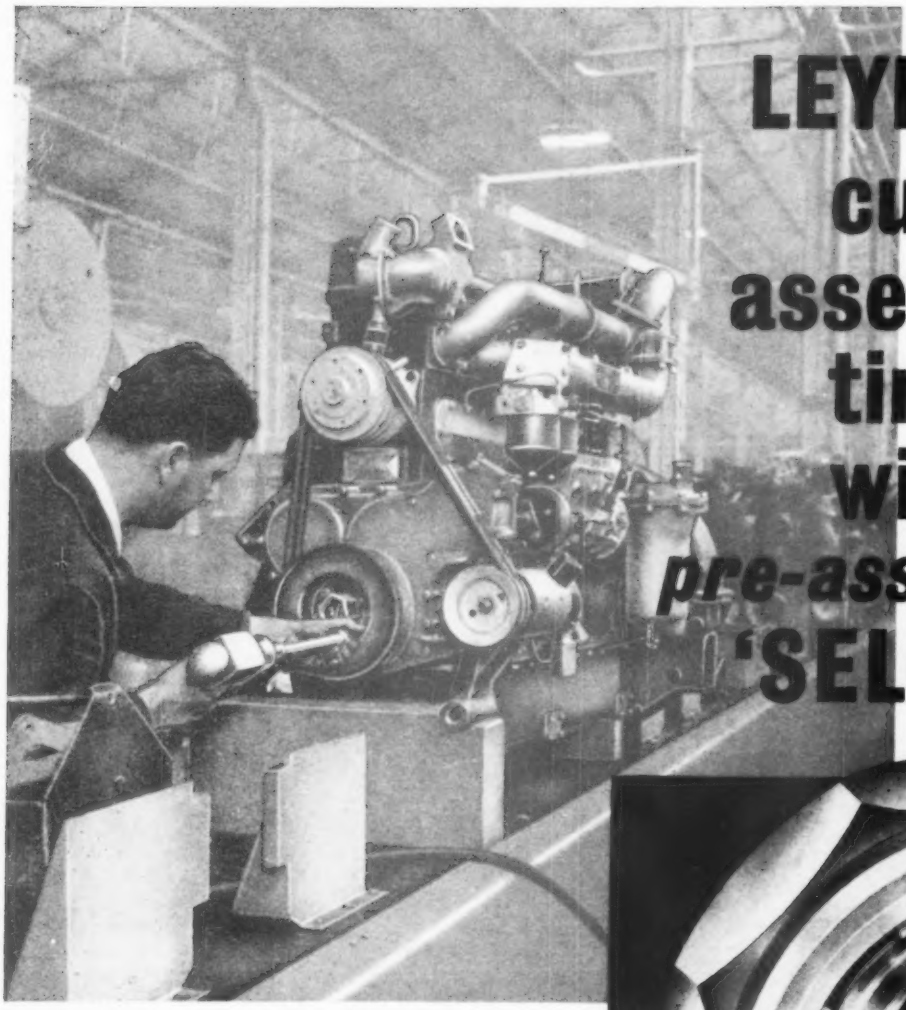

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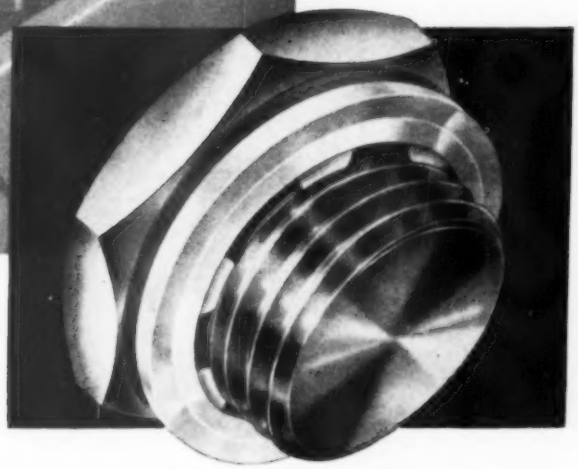

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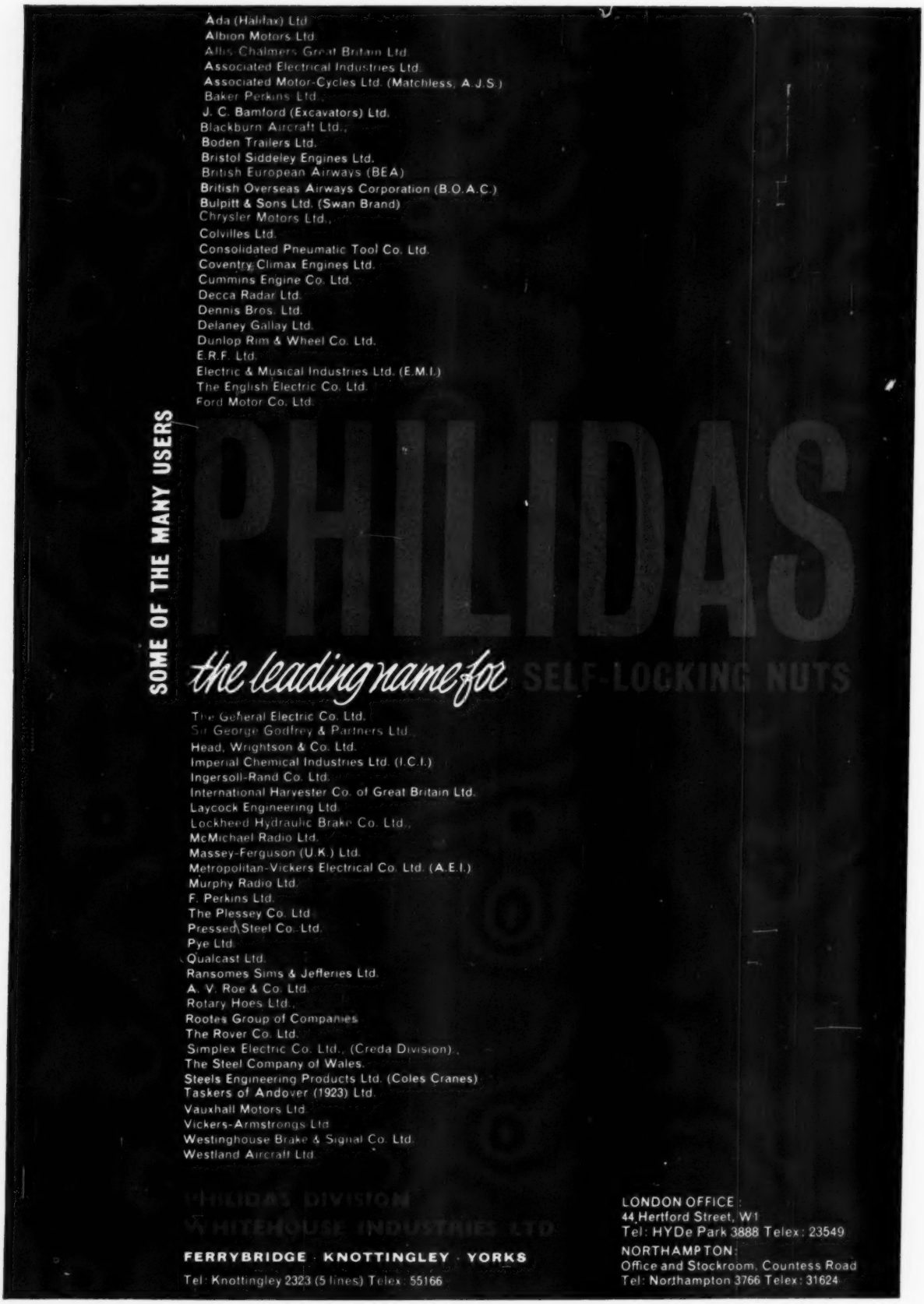
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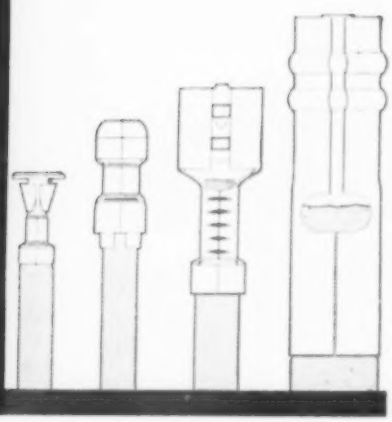

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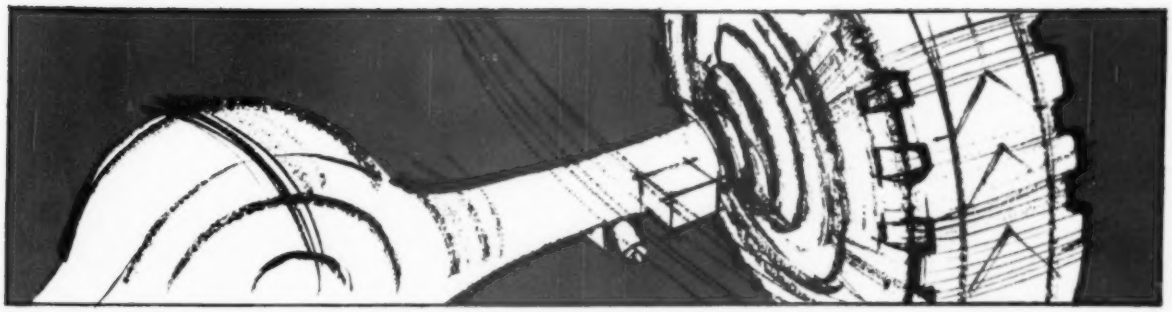

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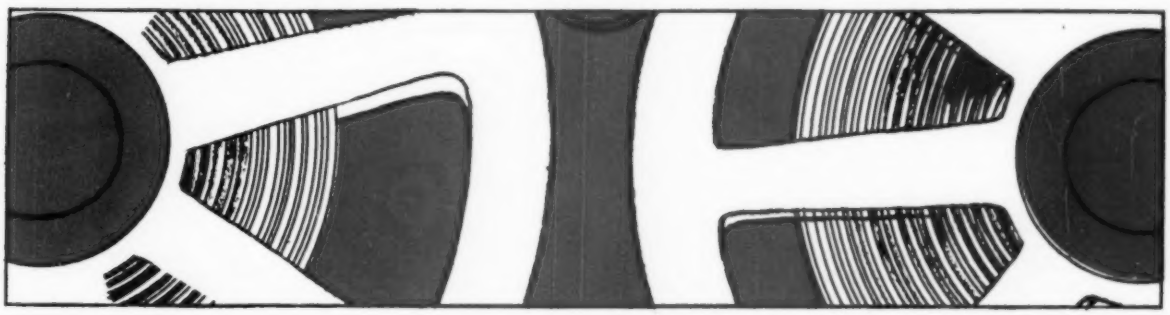

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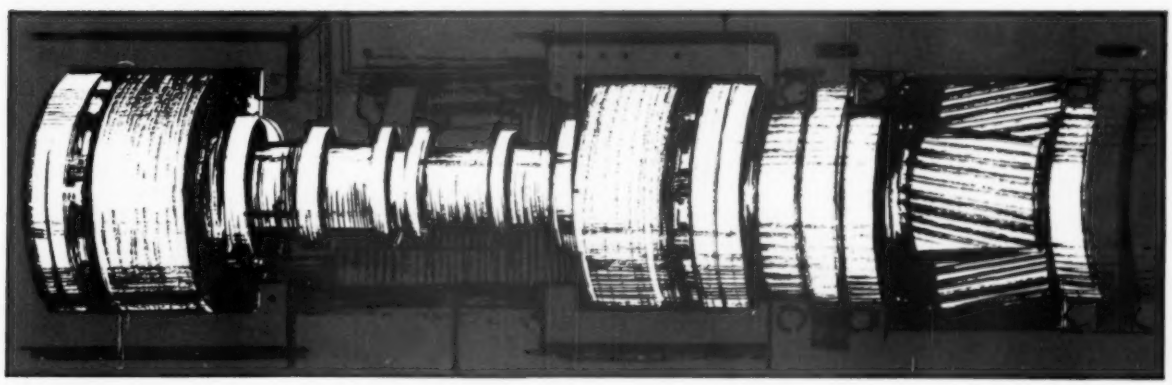

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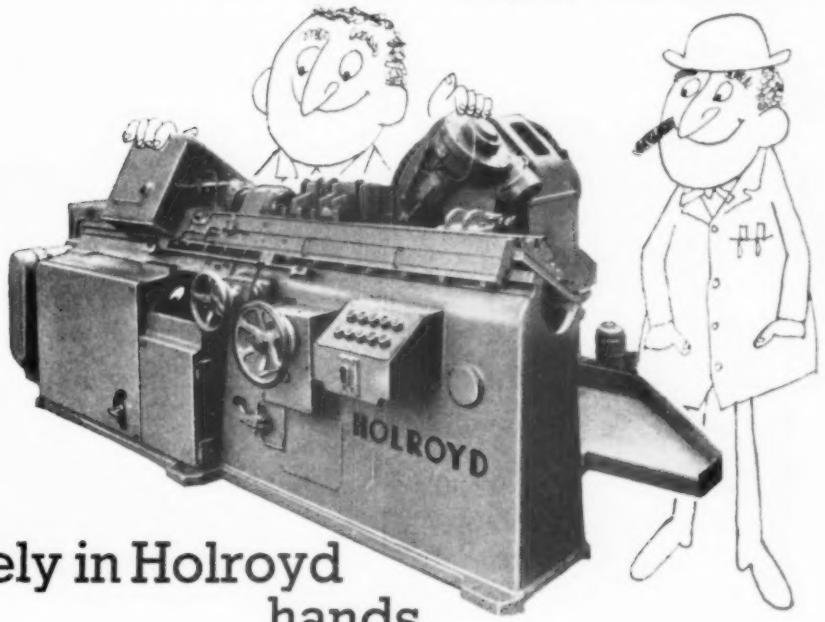

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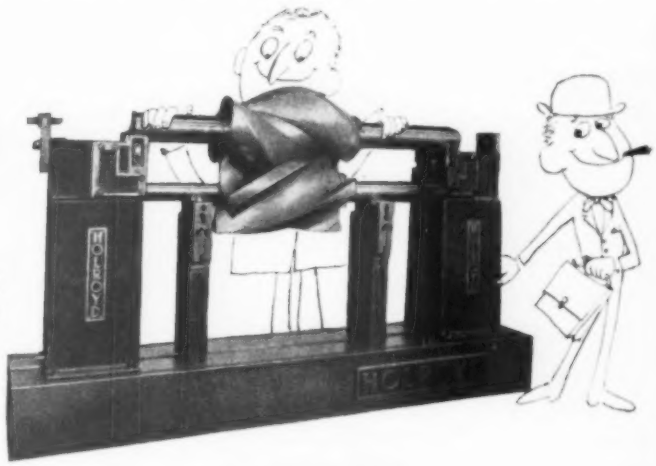

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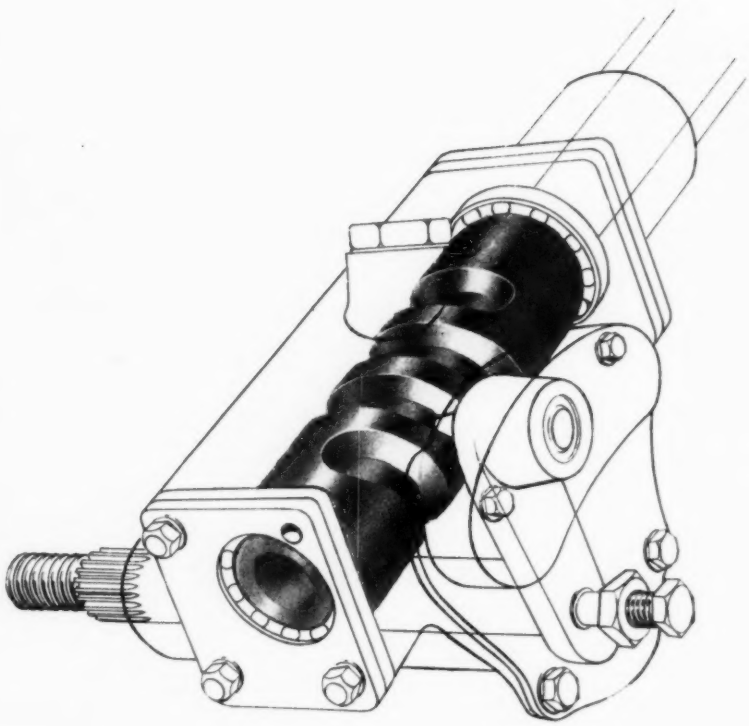

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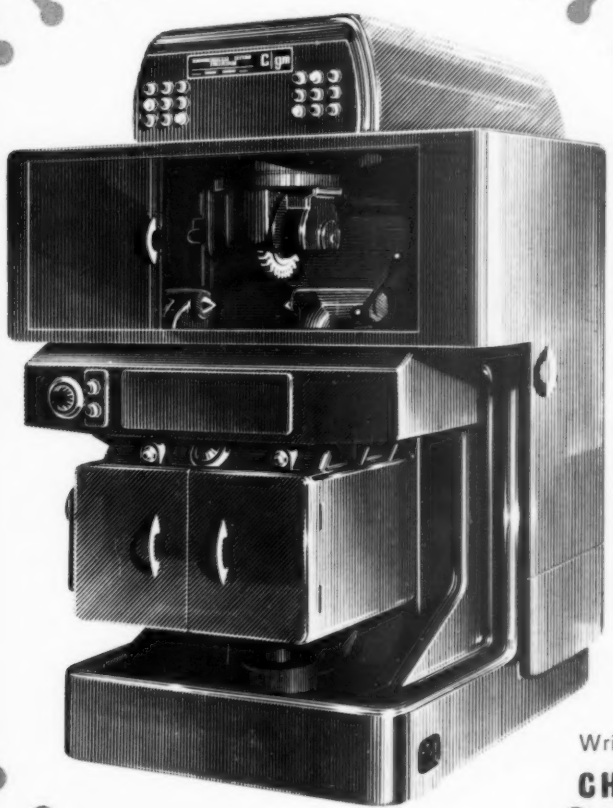

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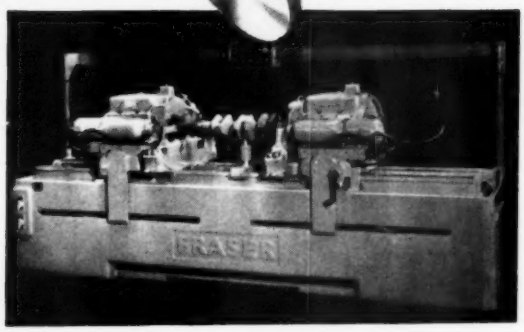

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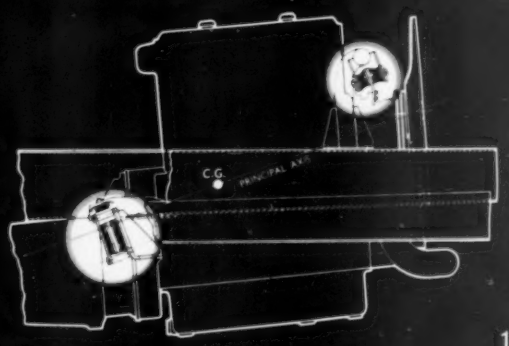
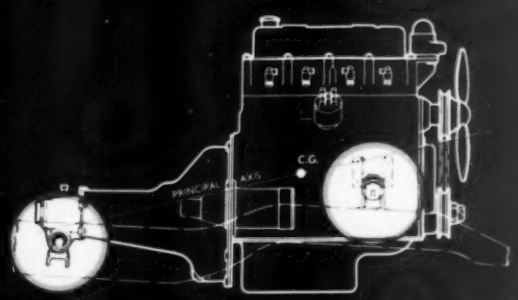


1

If practical considerations could be ignored there would be no problem in providing the ideal suspension for every motor vehicle engine. Mountings would be disposed symmetrically about all three principal axes of inertia and fitted on the longitudinal axis on the lines of "Floating Power" — the suspension technique developed by Metalastik in this country Such an arrangement is not often convenient and the most successful engine suspension is generally a compromise, simulating as closely as possible the characteristics of the ideal but respecting the claims of easy installation and other technical and economic factors so often at variance with theoretical perfection.

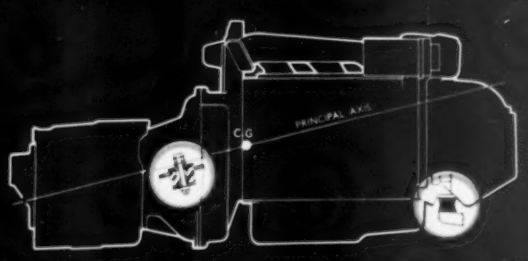
Examples of Metalastik suspension in Figs. 1, 2 and 3 illustrate how a combination of sound theory, appreciation of the practical and choice from an unequalled range of mounting units, bring maximum smoothness to different types of engine.



2

The suspension in Fig. 1 with the high front mounting resembles more closely the original "Floating Power" conception than is now usual. Secondary out-of-balance forces and a flexible chassis necessitate mountings with a large degree of vertical and rotational flexibility, hence the use of shear mountings at all three points. Pre-compression of the rear mountings permits higher stressing without loss of fatigue life.

Fig. 2 shows a typical suspension for a 4-cylinder motor car engine. Interleaved sandwich mountings are below the principal axis but 'focused' in 'V' formation to give the same rotational characteristics as mountings fitted higher but with their compression axes in a vertical plane. The Metaxentric bush at the rear controls fore-and-aft movement and has a higher deflection than a concentric type.



3

For the 3-cylinder opposed piston engine (Fig. 3) in which balancing has virtually eliminated the primary, vertical out-of-balance couple, slotted Metacones and the way in which they are fitted, provide high rotational flexibility about the vertical axis essential for insulation of vibration due to a horizontal out-of-balance couple.

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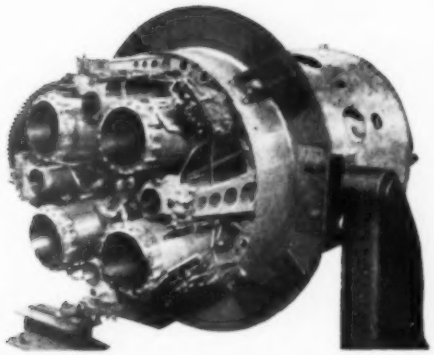

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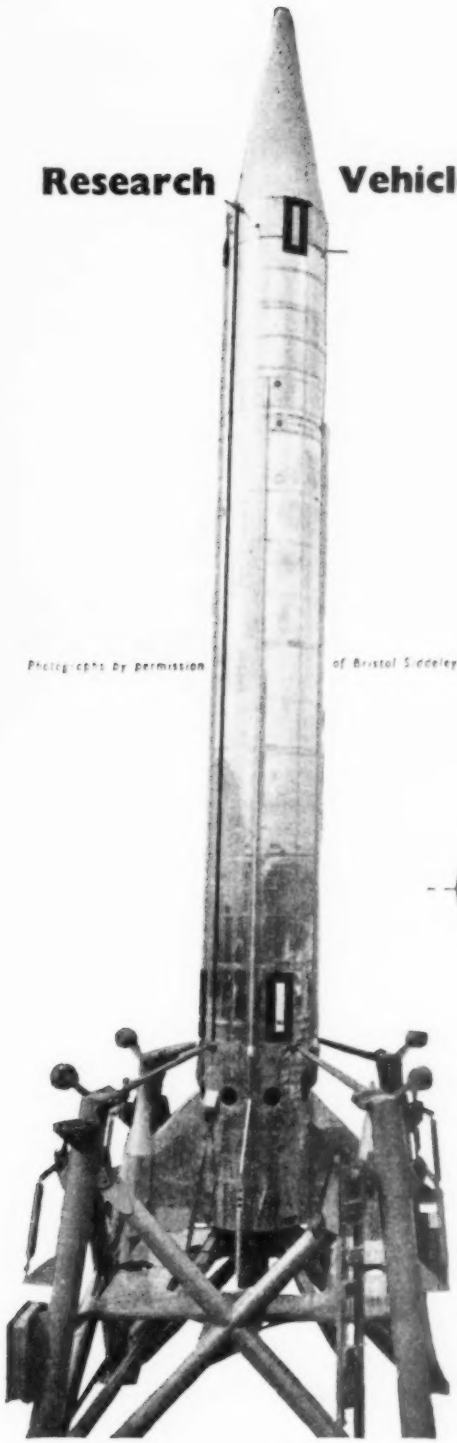

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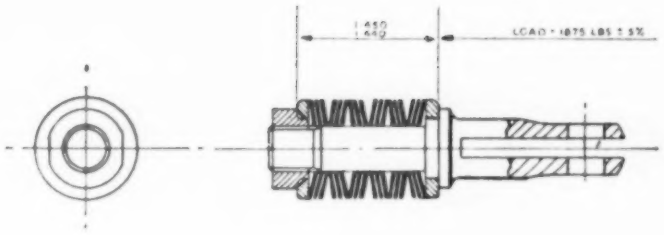

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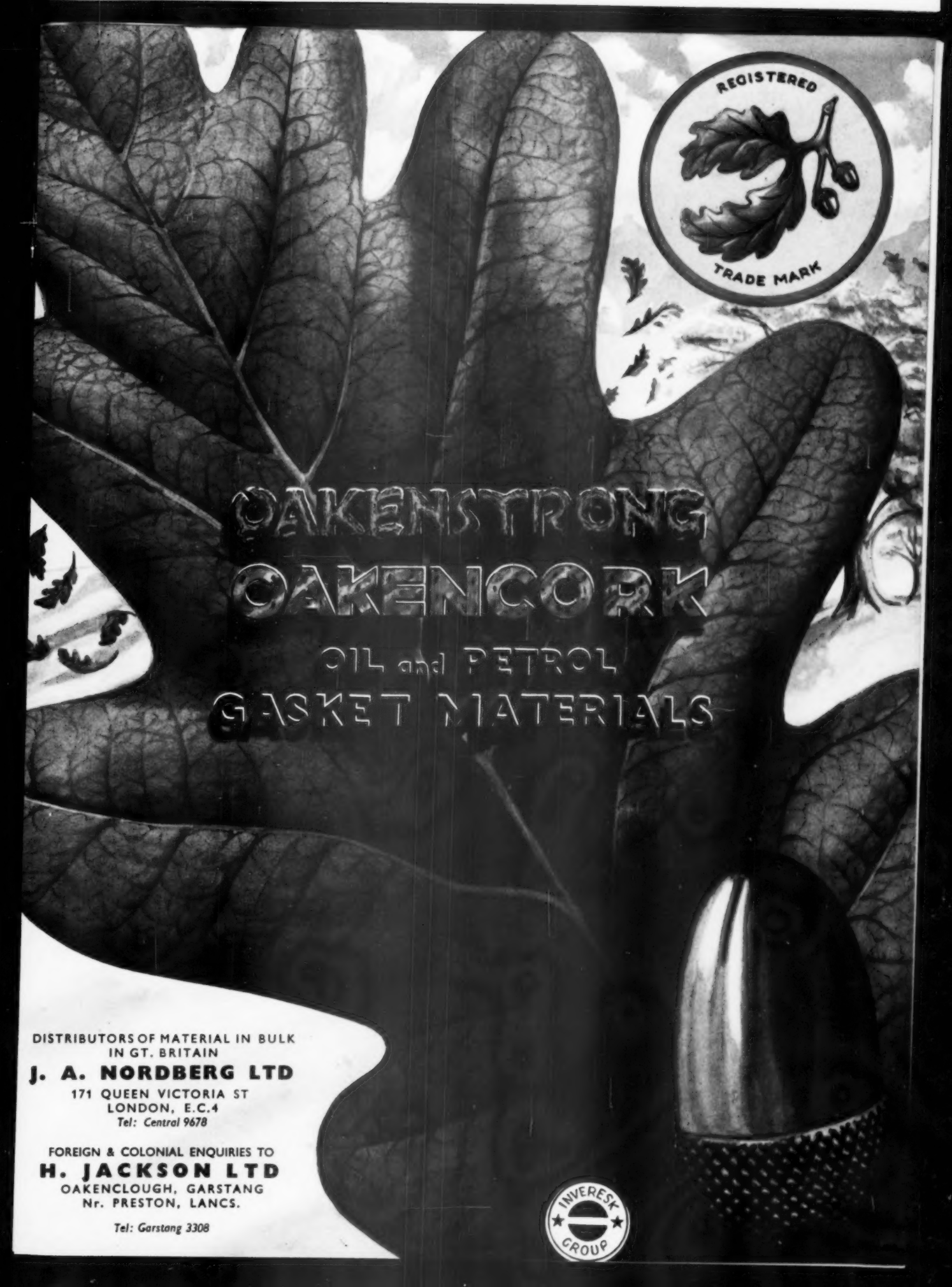

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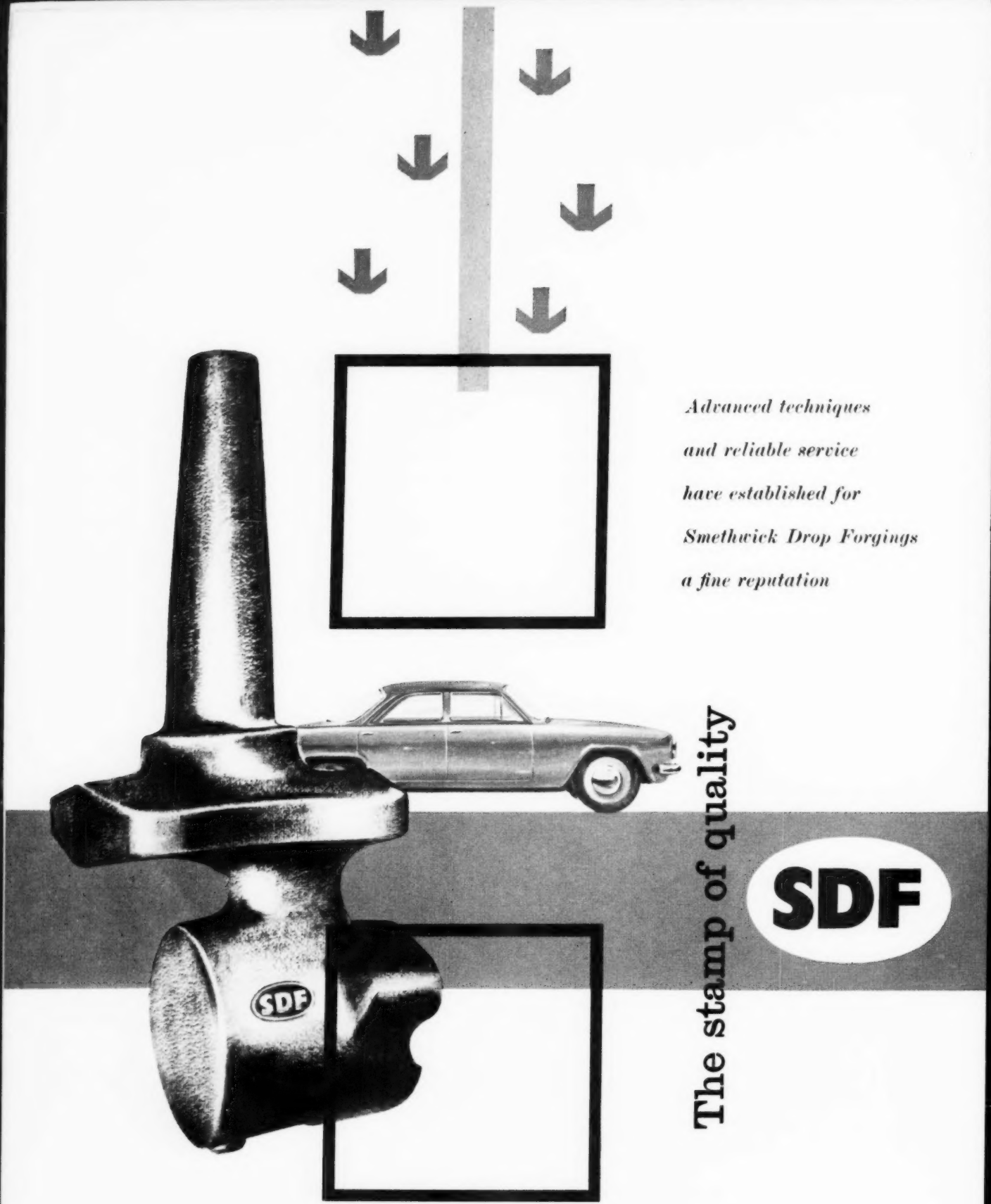

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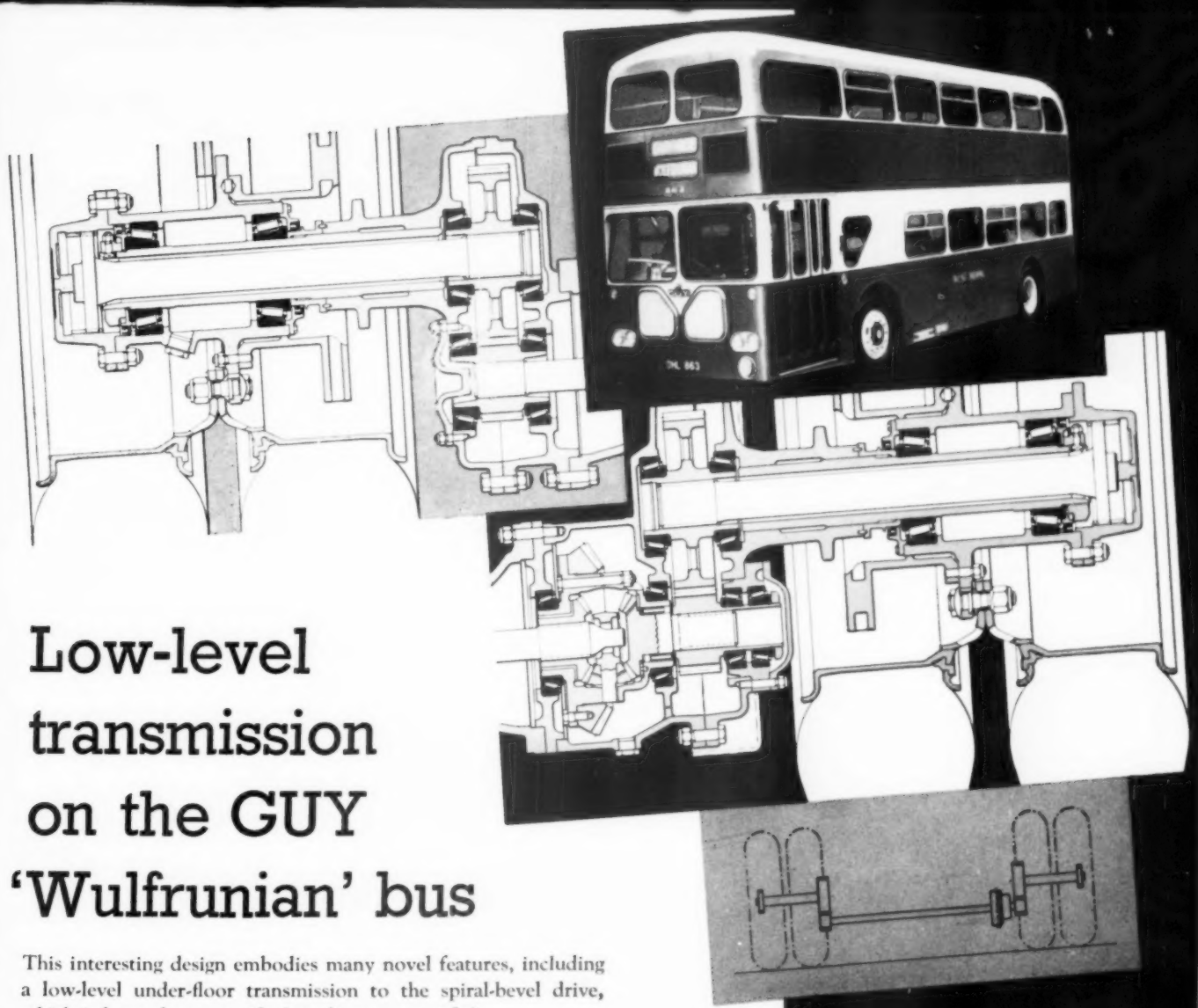

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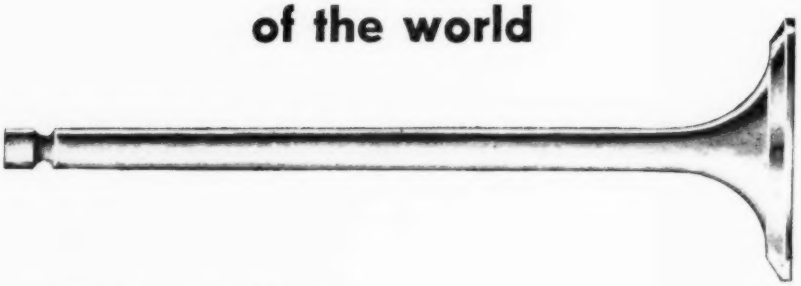

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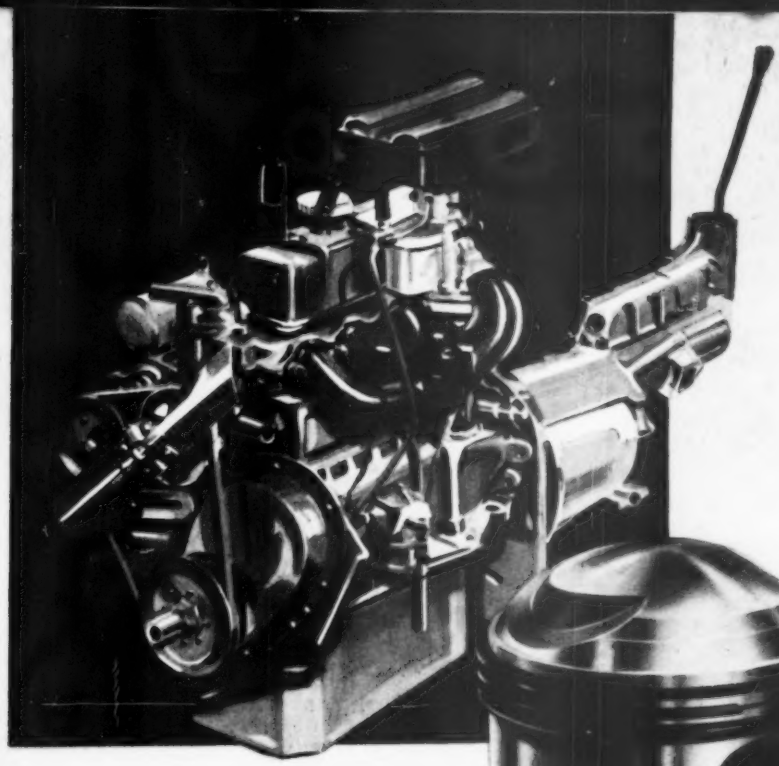

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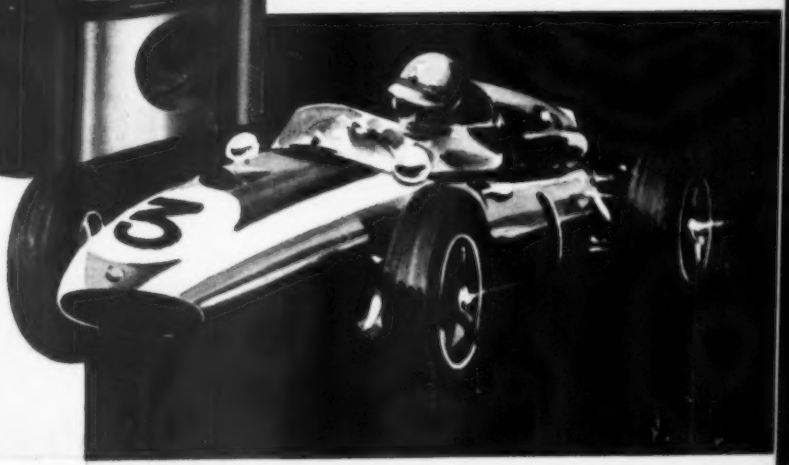

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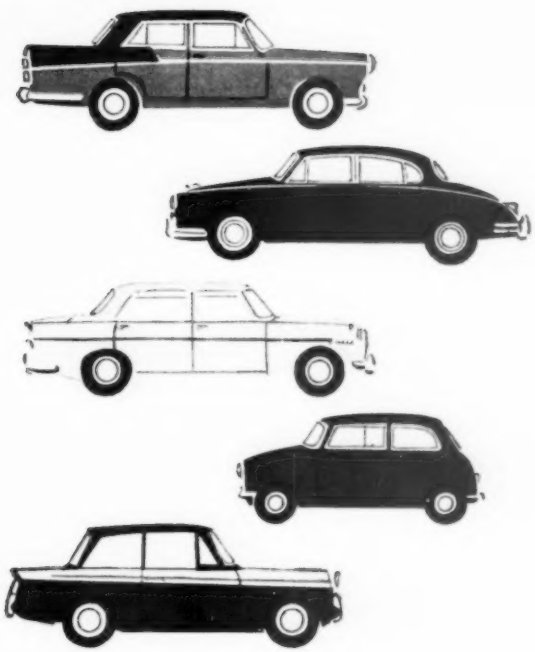

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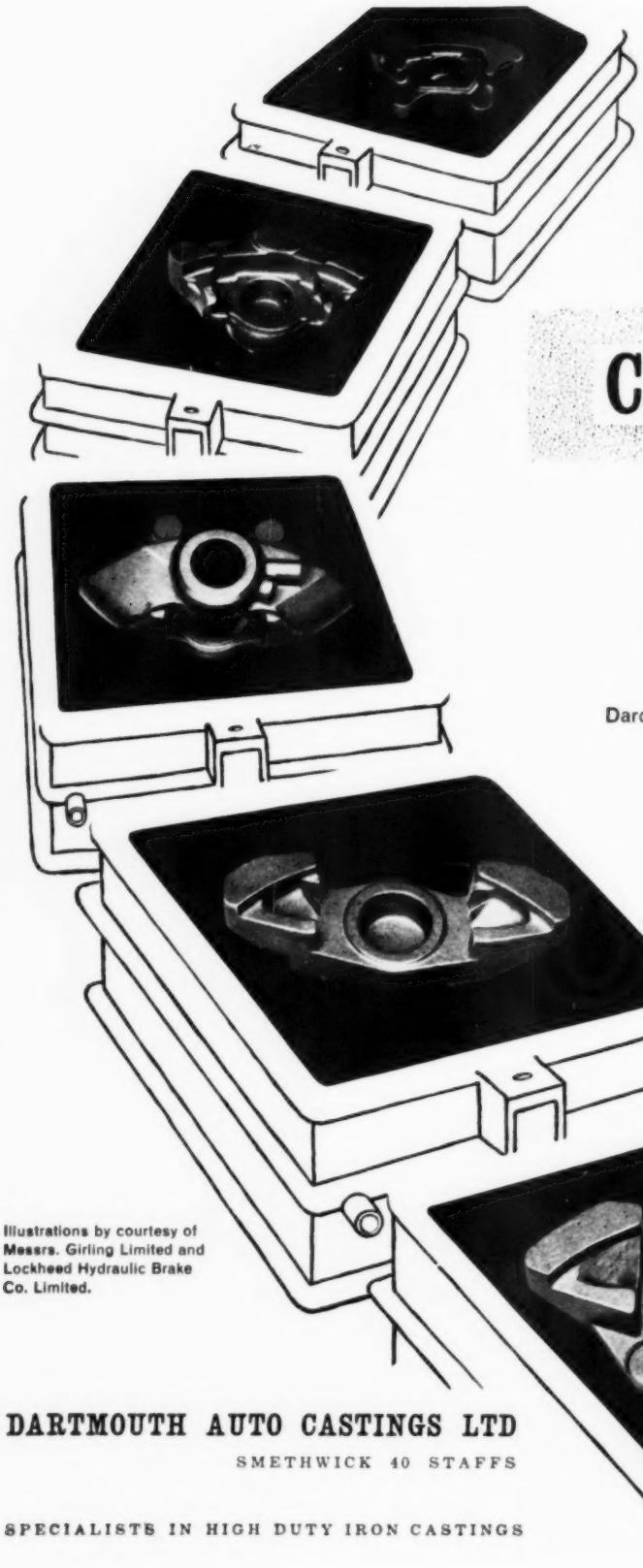

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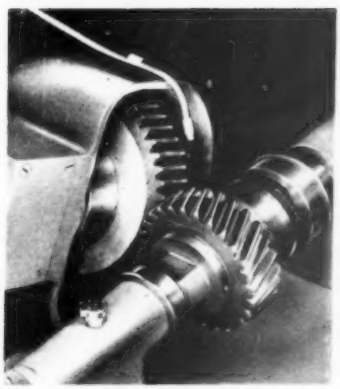

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DESIGN MATERIALS **AUTOMOBILE ENGINEER** PRODUCTION METHODS WORKS EQUIPMENT

Improvement of Chromium Plating

In Great Britain, stainless iron is being employed increasingly for certain applications and on the continent of Europe some manufacturers are using bright aluminium components; in the United States, the reputation of chromium plated components was at a particularly low ebb about 1957 but, as a result of considerable efforts, a certain degree of improvement in quality has been achieved. In all countries, there is some justification for customers' dissatisfaction with chromium plate, since that on pre-war vehicles was in many instances much better than that on the modern ones, and the question obviously is why equally good results are not obtained now. The answer of course is that better plating can be provided if the customer is prepared to pay more, but manufacturers producing vehicles in very large numbers at competitive prices feel that they cannot increase their costs significantly without losing ground in world markets.

Clearly, some benefit can be gained by the improvement of currently used processes. There are two key requirements: one is quality control throughout not only the whole of the plating processes, but also the manufacture of the component—if thoroughly carried out, this control, of course, obviates the need for final inspection — the second essential requirement is uniform distribution of the plating over the whole of the surface.

With regard to quality control, the need, of course, is attention to detail at all stages of manufacture. In this connection, it is helpful to have the plating shop close to that in which the components are made, and to avoid storage of components before plating or during intermediate stages, so that there is no trace of oxidation or other contamination on the surface of the component before plating. Another essential requirement is the removal of burrs and sharp edges before plating, otherwise uniform thickness of the overlay cannot be obtained—obvious, but how often is this the case?

So far as diecastings are concerned, a common cause of surface defects is over-polishing before plating: porosity immediately below the surface can be exposed by the removal of too much metal during the polishing process after the removal of the flashes.

Improvements in respect of uniformity of plating thickness should be obtained first by design—by avoiding complex profiles, re-entrant shapes and sharp edges and corners. It may appear trite to state that the advice of the platers should be sought at an early stage in design, so that specialist experience is brought to bear before it is too late, but does this always occur? Secondly, more can be done to improve plating techniques by the use of adequate jigs: in particular, benefits can be obtained by the more widespread use of shields, auxiliary cathodes, or robbers, and auxiliary anodes—in this connection auxiliary anodes of platinum coated titanium wire have been used and, although they are expensive, they are virtually everlasting. Close control of the arrangement of the components on the jigs and of the effectiveness of the electrical contacts is also essential.

As for the plating processes themselves, there is still a lot to be learned. Some years ago, it was thought that the inferiority of post-war chromium plate could be attributed to the substitution of bright for dull nickel plating. This assumption has been proved false. A thickness of 0·001 in of bright nickel, if properly applied, should be free from pores. Possibly, better results might be obtained by the employment of the duplex nickel plating process, that is, the application of a coating of bright nickel on a semi-bright layer, as the base on which to deposit chromium. However, this remains to be proved.

Undoubtedly, the most significant improvement can result from increasing the thickness of the chromium layer, which of course is the most resistant to oxidation. Recent research has made it practicable to apply chromium three or four times more thickly than hitherto, without serious cracking. For the avoidance of porosity, the chromium layer should not be less than 0·00003 in thick and should be applied on a 0·001 in layer of either bright or duplex nickel plating.

The questions that will be asked by all engineers are, exactly what improvements can be obtained by the modified and new processes being developed and will they justify the extra cost involved? It seems that the durability of plating would be appreciably improved by the most effective of the measures that have been outlined, which is the application of a thicker layer of chromium. This could be of particular significance to manufacturers who have increased their initial guarantee period to twelve months, and who are therefore especially anxious that components should remain longer in the *as new* condition. However, even when all practicable measures have been taken there will still be no grounds for complacency.

AUSTIN-HEALEY SPRITE

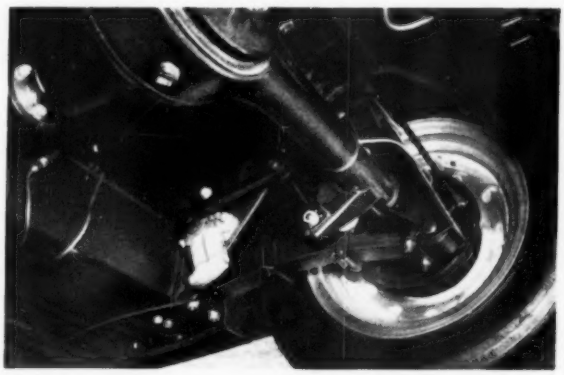
Part II: Details of the Rear and Front Suspension Systems, Rack and Pinion Steering Gear, Brakes and Electrical Equipment

By current standards, the rear suspension of the Sprite is unusual, in that quarter-elliptic springs are used in conjunction with trailing links. Each spring has 15 leaves of En.45 steel, the width of the leaves being 1¼ in. The master leaf is, of course, at the bottom, and it and the next four leaves are ⅛ in thick; the remaining leaves have a thickness of ¼ in. Measured to the centre of the eye, the overall length of each spring is 20¼ in, and the free length from the rearmost point of the anchorage is 16¼ in.

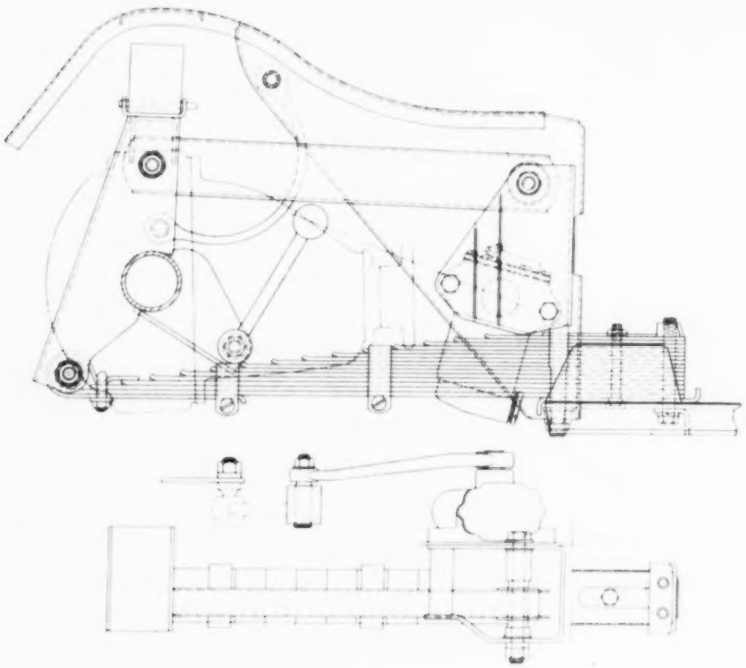
For mutual location of the leaves, a single bolt passes through them all near their leading ends. Towards the rear end of the spring, a clip embraces the first six leaves and the safety leaf, which will be described in the next paragraph. Nearer the front end of the spring, a second clip embraces 11 leaves. Each of these clips is located longitudinally on the spring by a set-screw in a tapped hole in the topmost leaf concerned.

The master leaf has the usual rolled eye. To reinforce the eye against fracture, and to provide a measure of safety in the event of such failure, a short safety leaf is provided. This is of similar material and section to the master leaf. Most of it lies underneath the master leaf; its leading end is just ahead of the first clip mentioned previously, and is turned downward to avoid any concentration of stress locally in the master leaf. The rear end of the safety leaf is curled upward round the eye, and then down in front of it and up again, to form a shallow channel; finally, it runs out horizontally to terminate over the end of the third leaf. A U-bolt fits in the channel, and so is located on the spring assembly. Before the nuts are assembled, a drilled plate is fitted over the free ends of the U-bolt; tightening of the nuts thus clamps the upper and lower arms of the safety leaf on to the leaves of the spring.

There are interesting features in the attachment of the spring both to the body structure and to the axle. The leading end of the spring passes horizontally through an aperture at the bottom of the rear cross member of the under-frame assembly. A ribbed and flanged 10 s.w.g. reinforcing plate of B.S.1449 En.2B steel is fitted under the floor panel at this point, and two B.S. R.45/55 steel bolts of ⅜ in diameter are fitted from beneath, passing through that plate, the floor and the spring; their upper ends screw into tapped holes in an attachment plate immediately above the top leaf of the spring. There is a hole in the centre of this



Above: This view of the rear suspension shows the anchorages of the spring to the under-frame structure and to the bracket on the axle, the damper mounting and its linkage. Beneath the floor of the boot can be seen the bump stop abutment plate



Left: The general arrangement of the rear suspension, in the static load condition. Two bolts and a U-bolt are employed to secure the fixed end of each spring, and the floor is reinforced to deal with the static and dynamic loadings transmitted to it. The safety leaf fitted round the eye is an unusual feature of the spring

SPECIFICATION

SUSPENSION: Front, double transverse link, with coil springs and Armstrong lever type dampers; upper links formed by damper arms. Rear, quarter-elliptic leaf springs and trailing links, with Armstrong lever type dampers, and rebound check straps.
STEERING: Rack and pinion. 2¼ turns of steering wheel from lock to lock. Turning circle, 31 ft.
BRAKES: Lockheed hydraulic, with 7 in diameter drums; front brakes have two leading shoes, rear brakes have leading and trailing shoe layout. Shoe width, 1¼ in; total swept area, 110 in². Hand brake actuates rear shoes through mechanical linkage.
WHEELS: Steel disc, with four-stud attachment and 3·5 in wide rims. Dunlop tubeless tyres, 5.20—13 in. Pressures: front, 18 lb/in²; rear 20 lb/in².
DIMENSIONS: Wheelbase, 6 ft 8 in. Track: front, 3 ft 9⅞ in; rear, 3 ft 8⅞ in. Overall length, 11 ft 5½ in. Overall width, 4 ft 5 in. Overall height, hood raised, 4 ft 1¾ in. Ground clearance, 5 in. Frontal area, 13·8 ft². Kerb weight, with 6 gals fuel, 1,466 lb. Weight distribution: front, 54 per cent; rear, 46 per cent.

plate, to clear the nut of the leaf-locating bolt. A U-bolt fits over the rear end of this attachment plate: its two arms embrace the spring and pass through the floor and the reinforcing plate. Self-locking nuts are employed for tightening the U-bolt.

Each spring eye houses a pivot bearing of the bonded rubber type. Through the inner sleeve of this bearing is fitted a bolt, whereby the spring is anchored to the bottom end of a channel-section bracket welded to the axle casing. This channel, which leans slightly forward from the vertical, serves several purposes. On a bracket welded to its upper end is fitted a bump rubber which limits the spring deflection by coming into contact with a reinforcing plate under the boot floor. A little below this bracket is the anchorage for the rear end of one of the trailing links which, together with the springs, locate the axle; the links also resist drive and brake torque reaction. Each link is a simple box-section member formed by welding two shallow channels together. At each end it carries a bonded rubber bush type pivot bearing; bolts passing through the bearings connect the link to the inner valance of the wheel arch and to the bracket on the axle.

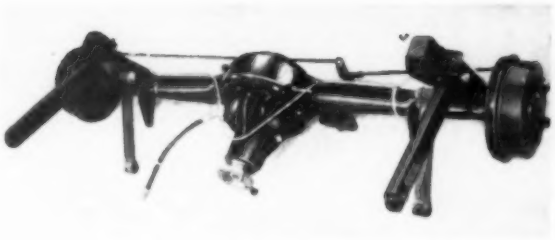
Projecting from the inboard face of each channel section bracket, between the link pivot and the axle, is the anchorage bolt for one of the rebound check straps, which are particularly desirable with this design of suspension. The lever type dampers are Armstrong D.A.S/8.RXP units. They are mounted on the under-frame structure and their arms are connected by ball-jointed links to brackets welded to the tubular portions of the axle casings.

The average rate of each rear spring is 97·8 lb/in. At a deflection of $3\frac{7}{8} \pm \frac{1}{8}$ in, the working load is 375 lb; the deflection to full bump is 6¼ in. A periodicity of 95 c/min is quoted by the manufacturers of the vehicle.

Front suspension

Following the B.M.C. policy of rationalization, the front suspension is basically that of the Austin A.35 and A.40 cars. Although the Sprite is lighter than the A.35, it has the same springs, since a rather firmer ride and less cornering roll were regarded as desirable characteristics. This suspension is of the double transverse link type; the lower links, of wishbone form, embody the abutments for the lower ends of the springs and are considerably longer than the upper ones which, in fact, are the lever arms of the dampers.

At the top and bottom of the steering swivel pin are trunnions for the wishbone mountings. The axis of the lower trunnion is inboard of the swivel pin, with which it is integral. Carried in the boss of this trunnion, and located by a cotter pin, is a spindle with threaded ends, which are

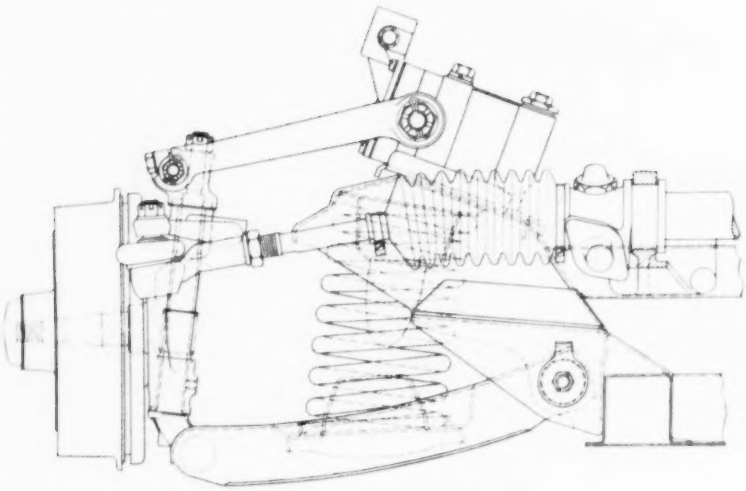


Whereas the pivot bearings of the trailing links are between the bracket flanges, the rebound check straps have an overhung mounting

screwed into sleeves welded to the outboard ends of the arms of the lower wishbone. These threads, which are of different diameters for assembly purposes, provide the necessary bearing surface and a means of axial location. The outer end of each sleeve is closed by a cap, and one of these caps is fitted with a nipple for lubrication. Oil reaches the threads through an axial hole and two radial holes in the pin. Thrust washers are fitted between the arms of the wishbone and the faces of the trunnion boss.

The lower wishbone is a pressing of 14 s.w.g. steel, A-shape in plan view; the arms are of channel section, with their flanges pointing downwards. At the inboard ends of the arms are sleeves, each of which houses the two rubber bushes forming the pivot bearing. As was mentioned in the description of the under-frame structure, the pivot brackets —of channel section—are both welded to the appropriate spring abutment bracket. The flanges of the bushes fit between the sleeve and the bracket flanges. Each pivot bolt passes through both flanges of the channel as well as through the wishbone sleeve, although the rubber bushes prevent it from touching them. To accommodate the ends of the bushes, the holes in the bracket are larger than the pivot bolt. On the outside face of each flange of the bracket, a washer with a tag is fitted to the pivot bolt. The tag is bent over at right angles to register in a rectangular hole in the flange, so that the washer is prevented from turning. When the castellated nut on the pivot bolt is tightened, the two washers squeeze the rubber bushes, so that they fill the holes in the bracket and the bore of the sleeve. It is a service instruction that these rubber bushes should be renewed when lateral movement of the wishbone or softening of the rubber become evident. The inboard bearings of each wishbone are spaced

When the one-piece bonnet and front wing assembly is raised, good access can be gained to the front suspension and steering, as well as to the engine. The air intake for the heater is mounted on one side of the radiator, and the screen washer reservoir on the other



The front suspension is generally similar to that of the Austin A.35 and A.40 cars, and the damper arms form the upper links of the system. At their lower ends, the springs abut on detachable pressings, so that they can be removed without the need of disturbing the linkages in any way

approximately 8 7/16 in apart, and the centre distance between their axis and that of the trunnion bearings is 10 3/8 in.

Towards the upper end of the En.12 swivel pin, the diameter is reduced at a shoulder, and the top of the portion of the pin above the shoulder is threaded. On to this portion is fitted the upper trunnion member; a washer of the appropriate thickness is interposed between the trunnion member and the shoulder, to provide correct clearances when the axle swivel assembly is installed on the pin. Three standard thicknesses of washer, varying from 0·003 in to 0·012 in, are available.

The trunnion member is clamped on to the shoulder on the swivel pin by a castellated nut. Its pivot pin is sited outboard of the swivel pin axis, and is carried in the trunnion by a pair of rubber bushes; the pin extends forward of the trunnion to accept the outboard end of the arm of the Armstrong I/S.9/3RXP lever type damper. This arm is 7 3/32 in long between centres, and the attachment eye is slotted and is fitted with a pinch bolt. To prevent the pivot pin from turning in the arm or from moving axially, the pinch bolt also acts as a cotter.

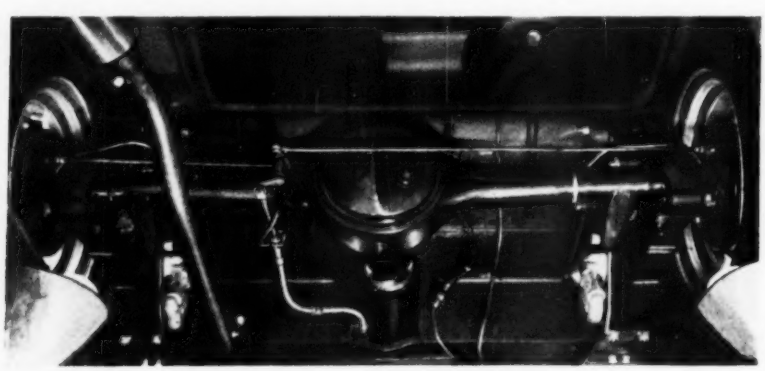
In the web of each lower wishbone is a circular aperture, the periphery of which is flanged upwards. This opening is in the middle of an approximately square depression in the web, and its diameter is slightly larger than that of the helical suspension spring. The 14 s.w.g. steel pressing that forms the spring seat is secured to the underside of the web by four 5/16 in bolts, fitted with serrated washers and nuts. This pressing has a down-turned peripheral flange, for stiffness, and a relatively deep medial dome, which projects upward through the web aperture. As full upward deflection of the wheel is approached, the dome comes into contact with the rubber bump stop, which is mounted within the spring, on its abutment on the under-frame structure.

Because the spring does not seat directly on the wishbone but on this separate pressing, it can be removed or replaced without disturbing the links. To do this, the load is taken off the wheel, after which two of the four spring seat bolts are removed and replaced by two much longer bolts or the special tool available. On removal of the remaining two bolts, the spring seat can be lowered until the spring itself is completely unloaded. The spring seat can then be detached and the spring withdrawn downward through the aperture in the wishbone.

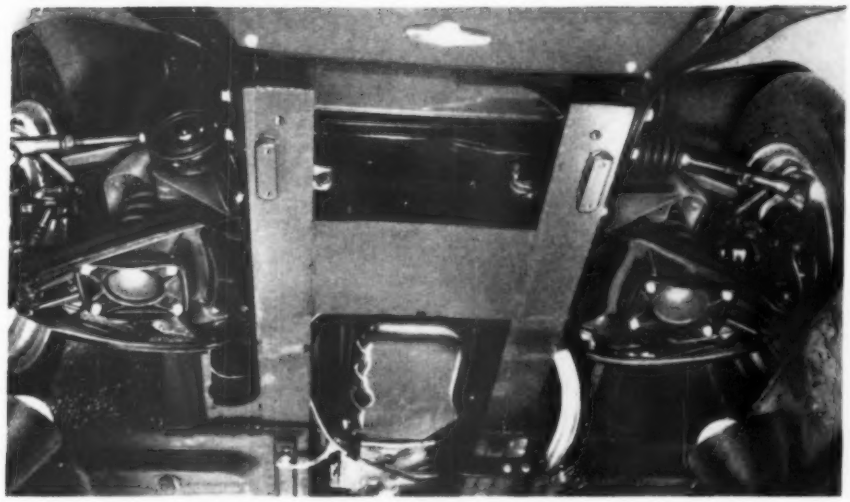
The suspension spring is of En.45A steel: it has seven free coils of 4 1/8 in overall diameter, and the wire diameter is 0·5 in. Its free length is 9·4 in and the coil-bound length is 4·25 in. As installed, with a wheel load of 750 lb, the spring has a length of 6·625 in. The spring rate is 271 lb/in, giving a rate at the wheel of 71 lb/in.

Carried on the swivel pin is an En.15R steel forging, which embodies the stub axle. It is fitted with upper and lower Clevite bushes, each of which has its own lubrication nipple. The lower bush is approximately 1 1/2 in long and has a bore of 0·68 in. In the upper bush, which is 1 1/8 in long, the bore is only 0·62 in, this reduction being chiefly for convenience in assembly. An Oilite thrust washer, of approximately 1·19 in outside diameter, is fitted between the top of the forging and the upper trunnion.

As will already have become clear from the foregoing, the



For the mechanical actuation of the rear brakes, bell-crank levers are incorporated in the hydraulic cylinders. The levers are coupled by rods to a balance lever, mounted on the axle casing; connection to the hand lever is by enclosed cable



The lower wishbone links pivot in rubber bearings carried on the under-frame longitudinals; underneath them can be seen the detachable spring abutments. On top of the longitudinals is the rack and pinion steering unit

swivel pin is assembled upward into the forging. Between its lower end and the shoulder already mentioned, it has three slightly different diameters. The largest diameter is at the bottom, where the pin is embraced by the lower bush. Above that, the intermediate diameter is shrouded by a telescopic dust excluder, the two tubes of which are pressed into their seatings on the forgings by a helical spring. Above this intermediate portion is the still smaller diameter, matching the bore of the top bush. A sealing ring is fitted between the bottom bush and the base of the swivel pin.

The standard settings of the various steering angles are: swivel pin inclination, 6½ deg; camber angle, +1 deg, castor angle, +3 deg. The axes of the swivel pin and the hub intersect, and the trail or castor dimension, with the standard 5.20—13 tyre, is approximately 0·6 in. The camber angle changes to 0 deg at full bump and to $-\frac{1}{2}$ deg at full rebound, and the maximum variation of track with suspension movement is $\frac{1}{32}$ in.

Two ball bearings of different sizes carry the wheel hub on the stub axle. Both are of Ransome and Marles manufacture and the inner race in each case is located axially. At the swivel end of the axle is a shoulder against which the inner race of the larger, inboard bearing is held by a distance sleeve fitted between the two bearings. The inner race of the smaller bearing is clamped against this distance sleeve by a tongued washer and a castellated nut, secured by a split pin. To take thrust in one direction, the outer races are of the lipped type; they are pressed into the hub against shoulders. Inward thrust is taken by the inboard bearing, and the outboard bearing takes outward thrust.

Steering

The rack and pinion steering layout employed is similar to that which has proved so successful in the Morris Minor car. An En.16U steering arm is attached to each swivel member, above the hub axis, by two $\frac{3}{8}$ in U.N.F. set-screws passing through drilled bosses in the arm and entering tapped holes in the member. The two screws are locked by a single tab washer. These arms extend forward and are splayed outward to provide an Ackerman geometry. The leading end of each arm is situated between the wheel rim and the brake drum.

A short adjustable tie rod, with a ball joint at each end, connects the leading end of each steering arm to the appropriate end of the rack, which is made from En.8 steel. The rack has helical teeth and is carried in plain bearings in a cylindrical, cast iron housing. A synthetic rubber bellows fitted on each side the rack unit, between the end of the housing and the tie rod, prevents oil leakage and the entry of dirt or moisture.

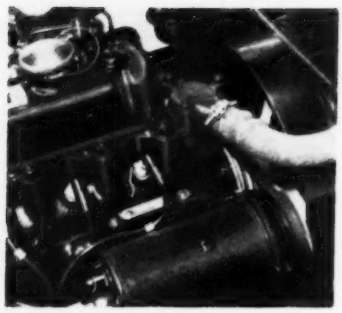
The 8-tooth pinion, made from case-hardening nickel-chromium steel, is integral with its shaft, and has a helix angle of 5½ deg. Both ends of the shaft are supported—the upper portion by the tubular steering column, and the lower portion, which is shorter and of smaller diameter, in a plain bearing formed in a flanged cap attached to the front of the rack housing by two set-screws. This cap also houses a bronze thrust washer. To adjust the axial location of the pinion, a shim of the appropriate thickness is fitted between it and the cap.

On the portion of the shaft above the pinion are fitted another thrust washer and an oil seal. The upper end of the shaft is splined and it fits into the correspondingly splined lower end of the steering column, which is reinforced and split to enable it to be clamped by a pinch bolt on to the shaft. Since this pinch bolt engages a circumferential groove on the shaft, the splines cannot disengage should the nut become slack. The steering column is carried in felt bearings, one in each end of the fixed, outer tube. A dust seal is fitted at the foot of the outer tube.

Two dampers bear on the rack. One of these is situated in the housing, above the pinion, and its effect is to control the backlash between pinion and rack. Under a screwed-in plug in the housing is a spring-loaded pad, which bears radially on the rack, pressing it into mesh with the pinion below it. The actual pressure is determined by the shim thickness between the flange of the plug and the face of its boss on the rack housing.

Adjustment is made with the pinion disconnected from the steering column and the rack disconnected from the road wheels. After removal of the pad spring, the plug is screwed home, with no shim under it, until the pinion can just be turned by moving the rack endwise. Then the gap between the plug flange and the boss is measured with a feeler gauge. This measurement, with the addition of 0·002 to 0·005 in, is a guide to the necessary thickness of shim. Standard shims of 0·003 or 0·010 in thickness are available. The plug is then unscrewed, the spring refitted and the plug screwed fully home after the appropriate shims have been added to it. The other damper is at the end of the rack housing remote from the pinion. It is not normally adjustable, and consists simply of a small spring-loaded plunger retained by a screwed-in plug.

The overall ratio of this steering system is such that



The belt drive to the dynamo is of normal type, and the fan is shrouded to increase its efficiency. Right-angle connectors are used on the plug leads

2¼ turns of the steering wheel are required to turn the road wheels from lock to lock, through a total angle of 62 deg. As can be seen from one of the illustrations, the rack unit is carried above the frame longitudinals, just behind the radiator. The rack housing seats in brackets to which it is secured by clamps; each clamp is retained to the bracket by two set-screws. For lubrication of the rack, a nipple is fitted at the end of the housing remote from the steering column.

Wheels and Brakes

Pressed steel wheels, of the perforated disc type, are fitted to the Sprite. They have a four-stud fixing, and their rim diameter and width are respectively 13 in and 3·5 in. Dunlop tubeless tyres, of four-ply construction and 5·20 in section, are standard equipment. For all normal running, the recommended pressures are: front, 18 lb/in², rear, 20 lb/in².

The Lockheed hydraulic drum braking system is of orthodox design. Drums of 7 in diameter are fitted to the front and rear wheels, and in each case the lining width is 1¼ in. Since the lining segments are each 6·75 in long, the total friction area is 67·5 in²; the corresponding swept area is 110 in².

In each front brake, the two-leading-shoe layout has been adopted, and each shoe is adjusted by means of a Micram stepped ramp fitted between the hydraulic piston and the tip of the shoe. A leading-and-trailing-shoe arrangement is employed in the rear brakes, and the method of adjustment is similar to that at the front. The proportions of the slave cylinders are such that 64 per cent of the braking effort is applied to the front wheels. In this connection, it is of interest that these wheels carry 54 per cent of the kerb weight of the vehicle.

The additional manual actuation of the rear brakes is effected through the medium of a bell-crank lever incorporated in an extension of each hydraulic cylinder; one arm of the bell-crank bears on the piston. To the other arm of each bell-crank is attached a transverse rod, and the inboard ends of the two rods are connected to the arms of a T-shape balance lever pivot mounted on a bracket. This bracket is bolted to a seating on the underside of the left-hand tube of the rear axle casing. The leg of the T is coupled by an enclosed cable to the hand brake lever, which is conveniently mounted between the seats, alongside the propeller shaft tunnel.

Electrical equipment

Little comment is necessary in respect of the standard electrical equipment which, with the exception of the sparking plugs, is of Lucas manufacture. The type C39PV2 12-volt dynamo, mounted on the right of the cylinder block, is driven at 1·35 times engine speed from the crankshaft by the belt that also drives the water pump and fan. It charges the battery through a type RB106/2 regulator and has a rated output of 19 amps at 13·5 volts; the battery has a capacity of 43 amp-hr at the 20 hour rate.

A spiral gear on the camshaft drives the type DM2P4 distributor, in the conventional manner. At first sight, the low and nearly horizontal mounting of the unit appears to be inconvenient, but its accessibility is, in fact, quite reasonable because of the manner in which the bonnet and front wings hinge upward as a complete assembly. The distributor has both vacuum and centrifugal control of the amount of spark advance; a 6 deg range is provided by the vacuum unit, whereas the centrifugal control has a range of 14 deg. High-tension current is supplied by a type LA12 coil, which is mounted on the right side of the engine compartment. The standard sparking plugs are Champion N5 components, having a 14 mm diameter thread and a reach of ⅜ in.

F.700 headlamps, with 42/36 watt bulbs, form the normal lighting equipment. They are carried in nacelles projecting above the bonnet profile; the depth of the nacelles is minimized by the pressing of a recess or trough into the bonnet panel in front of each lamp, to provide clearance for the beam. The combined side and direction indicator lamps are mounted low in the front wings, flanking the radiator grille. At the rear, the direction indicator lamps are separate from and below the combined tail and stop lamps.

Twin windscreen wipers are normal equipment; the blades move in unison and cover most of the area of the screen. Among the optional extra equipment is a Smiths fresh air heater, which incorporates distribution flaps, a booster fan and provision for screen demisting. Another extra is an H.M.V. radio, installed below the dash.

In Part I of this article, which appeared in last month's issue of *Automobile Engineer*, there is an error in the engine performance graph on page 278: the figures on the b.h.p. scale have half their correct value. The maximum gross power output should therefore be 42½ b.h.p, as was stated in the text, and not the 21¼ b.h.p. on the graph.

Countering Corrosion

DURING the last few years, a substantial volume of criticism has built up in the U.S.A. regarding the short life of exhaust silencers owing to internal corrosion. Among the remedies that are being adopted are the use of stainless steel and sprayed-on coatings of aluminium. Information has recently been received of a new and interesting constructional system being introduced by American Motors Corporation for the silencers of the 1961 Rambler cars. The reasoning behind this development is that corrosion starts inside the silencer, and the condensation that causes it is due to the relatively low local temperatures.

To protect the steel against acidic attack, the tail pipe and internal surfaces of the silencer are to be coated, by dipping, with a liquid ceramic compound. This ceramic layer is then solidified, and caused to adhere firmly to the steel, by stoving at 1,500 deg F. Next the silencer is insulated, to raise its internal operating temperature. The insulation comprises a layer of asbestos material, retained in position by a jacket of zinc-plated sheet steel.

Whereas hitherto the average life of normal silencers in the U.S.A. has been as little as 18 months, or even less, it is claimed that one of these new American Motors components should last as long as the vehicle. This estimate, of course, is based on the assumption that the ceramic coating does not become discontinuous as a result of vibration or accidental damage. A silencer of this type will inevitably cost appreciably more than one of less elaborate design, but because of its advantages it should be attractive to customers.

A noteworthy feature of the Arbarth body on the Fiat 2200 chassis is the arrangement of the twin lamps on each side at the front. To avoid an unduly wide wing crown, the panel is contoured to sweep closely round the peripheries of the lamps. The shape of the grille is such that the twin rectangular lamp installations below the headlamps on each side are not incongruous

Continental Coachwork

A Review of Recent Styling Trends and Other Features

CONTINENTAL coachbuilders generally do not, of course, make any attempt to compete with the manufacturers who produce saloon cars on a large scale. Instead, they concentrate their efforts almost entirely on the production of sports saloon and coupés, and racing bodies and other special types. Although the market in this field is small, it is, nevertheless, adequate for these manufacturers. It also suits them particularly well because, with special bodies in general and the coupé type in particular, there is more freedom with regard to proportioning in a pleasing, artistic way. Traditional types of line with large vertical radiator grilles of conventional form have almost entirely disappeared. Even Graber, who produce a wide variety of bodies of the traditional type on Alvis chassis, have this year introduced a model with the elongated rectangular form of radiator grille of more modern design.

The elongated rectangular type of grille is used almost exclusively on coachbuilt bodies on the Continent, the only variations being the incorporation of tiny replicas of the traditional radiators, of firms such as Alfa Romeo and Ferrari, in the centres of these rectangular openings. So far as front end design is concerned, the accent is mostly on bringing down the bonnet profile, and for this reason there are some bonnet lids with air intakes incorporated on them to provide clearance for the air cleaner but, presumably by virtue of the advent of short downdraught carburettors, there is less evidence of this device now than there was a year or two ago. Perhaps the most interesting new feature is the incorporation of twin side-by-side headlamps on each side. Good examples of this are the Abarth Fiat 2200 and the Italsuisse Volkswagen. In general, there has been no tendency to follow the Americans in the employment of excessively heavy chromium plated adornment, either at the front or on any other part of the body. On the contrary, the trend has been towards simplicity.

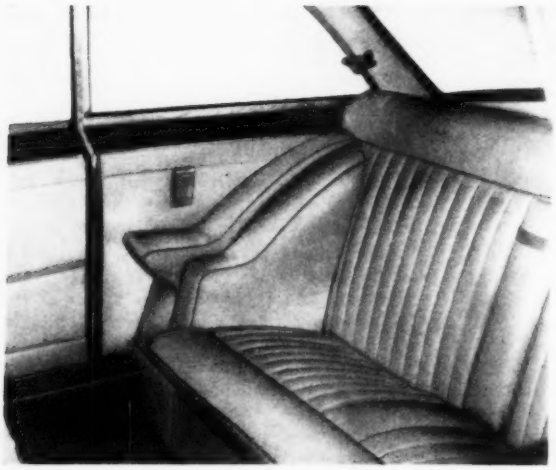
The rear end of the Abarth Fiat 2200 is typical of modern design, with neatly grouped lamp installations and a bumper section chosen to harmonize with the overall conception of the body styling theme

Considerable attention has been devoted to streamlining, especially on some of the high performance models. In view of the impracticability of streamlining adequately the tail end of the vehicle, there is not much evidence of radical departures from fairly conventional features there. However, front end streamlining is important, especially because eddies formed at the front, flow back over the whole length of the vehicle and appreciably increase the drag and wind noise. Another disadvantage of eddies at the front end is that they may tend to spray mud over the windscreen—in this connection, it is noticeable that windscreens of some cars become dirty and visibility is seriously impaired very rapidly when the road is wet, while others remain fairly clear.

So far as styling of the sides of the vehicles is concerned, there is a tendency to resort less to chromium plated strip and more to pressed lines on the panels. In fact, the modern trend is not to be content simply with lines but to employ deeper re-entrant pressed sections giving more emphasis to horizontal features. In most instances, the lines formed by these pressings extend from front to rear of the vehicle. In other words, the aim is at harmony and the avoidance of breaking the continuity of line.

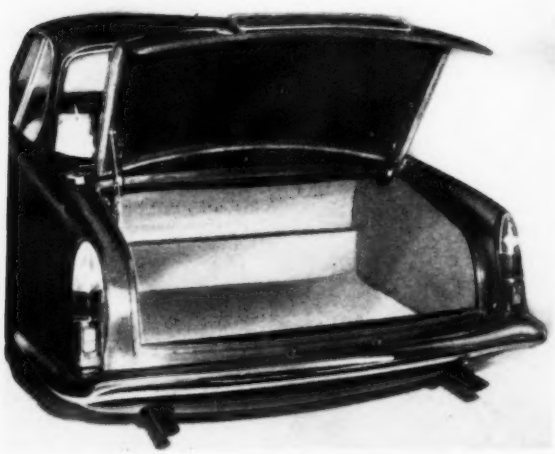
A noteworthy development in rear end styling is the accentuation of horizontal features to harmonize with the front end and side treatments. Another is the grouping of the rear lamps together in a single transparent, moulded plastics housing on each side. This grouping of the rear lamps gives a much neater and better finished appearance than the employment of separate stop and tail lamp units, and it can be more economical. A few manufacturers incor-

Even Graber, who for many years have been manufacturing bodies with traditional type radiator grilles on Alvis chassis, have now produced one with the modern rectangular form of grille on the same make of chassis. An interesting feature is the flat, reverse rake, drop glass in the rear light



The Gordon car, styled by Bertone, has a space frame, and among the devices adopted to enable the interior components to clear the members of the frame is the divided armrest on each side of the rear seats

The two petrol tank filler caps, one on each side, can be seen in this illustration of the rear end of the Bertone Gordon car. Both tanks fit behind the rear wheel arches, to make optimum use of space



porate the direction indicators in the bumpers, but most have them in the main group of lamps on each side. The latter arrangement, of course, is better not only from the point of view of appearance but also from the practical aspect in that, if they are in the bumpers, the lamps are liable to be damaged even if the bumper receives only a minor blow. It is of interest to speculate as to what might be done with regard to the grouping of the headlamps with the other lamps at the front. This has, of course, already been done on the Mercedes-Benz 220.

So far as the interiors of the latest vehicles are concerned, carpets of either the woven or rubber backed type are used extensively on floors, although plastics floor covering is, in some instances, employed at the front. Plastics head lining material is widely used, and in many instances it is perforated and fitted with a sound absorbant backing, generally stuck to the roof panel. Bucket type seats are provided in most instances, although there are some examples of divided bench type. The squabs of the front seats are almost invariably adjustable for rake. On the dash facia, emphasis is generally on simplicity, and there is a lot in favour of concealing some of the less frequently used controls beneath a hinged panel, or in some other way, to achieve the best possible effect in respect of simplification and tidiness.

Abarth

Among the new models produced by Abarth are two vehicles based on the Fiat 2200 chassis. Both are two-seaters with occasional seats at the rear for two more people, but one is a drop-head and the other a fixed-head version. The styling of the front end of the drop-head version is of particular interest because it represents a new layout for a four headlamp arrangement. Instead of having four headlamps of equal size, the outer two are larger than the inner two, and each pair is arranged at an angle from the horizontal in such a way as to reduce the width of the wing crown: the accompanying illustration shows how successfully this has been achieved. Below each pair are two more lamps of rectangular form, grouped together one above the other; one is the direction indicator and the other the parking lamp. This is a good example of tidy grouping of lamps.

At the rear, too, the lamps are neatly grouped, as can be seen from the illustration, but the direction indicators are in the bumpers. Simplicity is the keynote of the design, and both the front and rear bumper sections have been well chosen to harmonize with the lines of the body as a whole.

The grille opening is approximately rectangular in frontal aspect, with its upper two corners radiused to provide clearance for the lamps. It would appear that the portion of panel between these corners and the lamps might present some difficulty with regard to cleaning. The fixed-head

Avoidance of wide wing crowns has been the object of employing this obtuse angle V arrangement of the four headlamps on the Bertone styled, Gordon car

version of this vehicle, as exhibited at the Geneva Show, has a conventional twin headlamp arrangement. There is a direction indicator lamp beneath each headlamp, and the sidelamps are mounted in the grille.

Bertone and Beutler

Bertone are now producing a standard version of the Alfa Romeo Sprint Special racing car that they exhibited at Geneva in 1959. This version is styled completely differently, but the windscreen form and layout, which is particularly advantageous from the point of view of the wiping arrangements, is retained. As can be seen from the illustration, the curvature of the screen and the arrangement of the blades are such that a large area is wiped clean, even on the wrap-round portion of the glass.

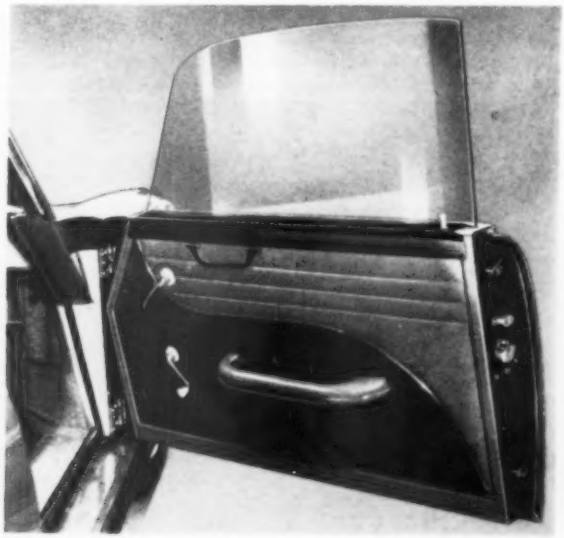
At the front end of this vehicle, a tiny version of the traditional Alfa Romeo radiator grille is incorporated in the air intake opening. This grille is flanked on each side by a horizontal bar, curved as viewed in plan, to match with the sweeping lines of the bumper below it. The well streamlined form of the previous model has been retained, but the layout of the rear end is slightly different. Reflectors are mounted on the rearward projecting ends of the wrap-round portion of the bumper, to simplify the appearance of the layout, and separate stop and tail lamps are installed, one above the other, just inboard of these. The ends of the central portions of the rear bumper, which extends horizontally along the lower edge of the skirt panel, are swept up, to joint the separate wrap-round portions extending forward to the wheel opening in the rear quarter panel.

Another body by the same coachbuilder is based on the special chassis designed by John Gordon, previously managing director of Peerless Cars. As can be seen from the accompanying illustrations, the twin headlamp layout is neat and the arrangement of the interior of the car is unusual. It would appear, however, that the V-arrangement of headlamps, especially when each pair is mounted on a single back-plate, presents a difficult problem with regard to the incorporation of the standard rectangular direction indicator lamps harmoniously below.

Because a space frame has been employed and there are two struts supporting the dash, the portion below the centre of the dash and between these struts has been boxed in to form a console containing all the instruments that are of secondary importance to the driver—the main instruments, that is, the speedometer, engine speed indicator, oil pressure and water temperature gauges, and two warning lamps, are retained on the panel above the steering column. The fuel

A console panel is accommodated between two of the space frame members below the centre of the dash in the Bertone body for the Gordon car

The styling of this door panel, by Beutler, is a masterpiece of balance and harmonious relationship between straight and sweeping lines



This Italsuisse body on a Volkswagen chassis is interesting because of the combination of American and European styling features. Evidently the relatively flat wing crown and bonnet arrangement has been adopted in order to accommodate the four headlamps

contents gauge, clock, and ammeter are mounted immediately below the top edge of the console panel and, under these three, are the heater controls and Lucas tumbler type switches for the electrical equipment. At the base of the panel is the radio and an ash tray with a spring-up, quick release lid. The face of the console is recessed, so that there is less likelihood of damage to the tumbler type switches, and its sides are well padded with insulating material.

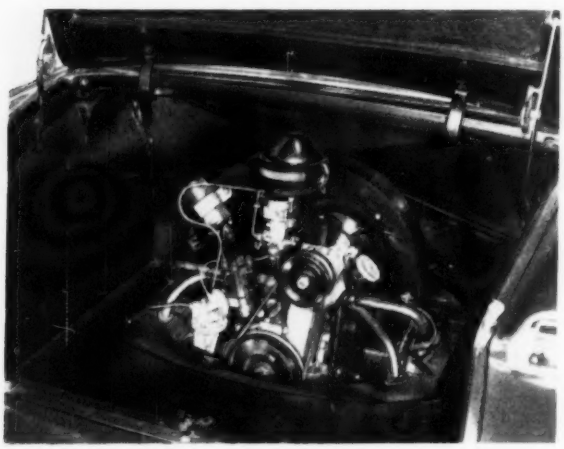
Again because of the employment of a space frame, the arrangement of the rear seats is unusual. The armrests on each side would have been unduly large, so they are divided, as can be seen in the illustration. The whole effect is neat, and the forward projecting parts of the outer portions of the armrests harmonize in appearance with the forward extension of the seat cushion. As is the case with most of the coachbuilt bodies, the rear quarter lights are hinged at their vertical forward edges, and secured at their rear edges by means of captive type toggle fasteners. This arrangement enables adequate ventilation to be obtained, but without draught, and it is much less complicated than the employment of a drop glass.

Beutler are renowned for their artistically proportioned bodies, the principal lines of which are of elliptical form. For many years they have been making bodies on the Porsche chassis, and on this year's models one of the noteworthy features is the styling of the door trim. The layout of this door is shown in an accompanying illustration.

It is a masterpiece of balance and harmonious relationship between straight and sweeping lines. The more or less rectangular shape of the door is divided into two areas by an S-shape bright metal finisher strip, which flows between diagonally opposite corners. Its arrangement is such that the area below it, which is the largest and is darker in colour than the upper part, is ample to carry the rather large armrest. At the same time, the sweeping outline of the D-shape armrest, which is accentuated by another bright metal finisher strip, harmonizes with that of the S-shape strip. Fitted to the trim panel immediately below the armrest is a glove box, the opening into which is formed by the armrest. Above it, the central portion of the S-shape is approximately horizontal, with the end nearest to the door hinge pillar sweeping up fairly sharply around the door release handle, and the opposite end sweeping down, with a large radius of curvature, to the lower corner of the trailing edge of the door. In this latter area, the relative proportions of the two parts of the trim panel are such that the upper one is the lighter in appearance. Thus, any suspicion of clumsy, top-heavy treatment has been avoided.

Along the top edge of the door is a finisher strip, of dark colour, and immediately below it is a capping that extends along the waist rail. This is balanced, at the lower edge of the door, by the bottom rail and a bright metal finisher strip. Three horizontal flutes in the upper portion of the trim panel, that is, immediately below the waist rail, serve three purposes: these are, to accentuate the length of the door, give a sense of unity to the arrangement of the door release handle and the exquisitely proportioned pull handle, and to show up to best advantage the curves of the S-shape dividing strip. Finally, the window winder is well placed in a large area of the lower panel, forward of the armrest. Even the door and hinge pillars give a display of symmetry when the door is open. Since, in many instances, the door when it is open is the first view of the interior that passengers have, its appearance in this position is, of course, of considerable importance so far as their impression of the car is concerned.

The neat rear engine installation of the Italsuisse styled Volkswagen



Italsuisse

A body that has been introduced recently and which has attracted considerable attention is that made by Italsuisse on the Volkswagen chassis. It is interesting because of the successful combination of American and European characteristics in a small car. The reason for the introduction of American flat deck characteristics at the front and rear of this design appears to be principally the accommodation of a four headlamp arrangement. A pair of headlamps is mounted side-by-side under an overhung, forward projection of the wing crown on each side. This overhung leading edge is continued horizontally, the whole width of the body, by a similarly forward projecting edge of the bonnet surround panel. The relatively flat wing crown formation is like that used on some of the Chrysler and American Ford models.

Flashing direction indicators are incorporated in the outer ends of the leading edges of the wing crowns. Between the two pairs of main lamps is an unusually simple imitation grille arrangement, with a plain bumper below. The upper horizontal edge of the grille is bounded by a chromium plated strip on the overhung extension of the bonnet surround panel, and the lower edge by another bright strip on a similar shape pressed in the skirt panel. Between the two is a horizontal, chromium plated bar, with a V-motif mid way between its ends, in line with the centres of the headlamps. The relatively high bonnet helps to compensate for the fact that space is inevitably restricted in the front compartment of a rear-engined car.

At the rear, the flat deck appearance is obtained by mounting the conventional rear lamp installations horizontally, instead of vertically, in the trailing edges at the upper portions of the rear wings. These lamps are in line with the chromium plated strip accentuating the horizontal overhung trailing edge of the boot lid, and also with a similar strip extending from front to rear on each side of the vehicle. There is an air intake on the top of the lid and the opening is finished with a chromium plated strip.

The trailing edge of the canopy is overhung to harmonize with the similar arrangement of the trailing edge of the upper portion of the lid of the engine compartment. Inside the vehicle, there is extra space for luggage behind the rear seat. This space is approximately 12 in as measured from the rear of the squab to the parcels shelf, and extends the full width between the wheel arches.

Bertone has re-styled the Alfa-Romeo Sprint Special, but the wrap round windscreen, with its particularly good wiper arrangement, which was exhibited at Geneva for the first time last year, has been retained

Pinin Farina

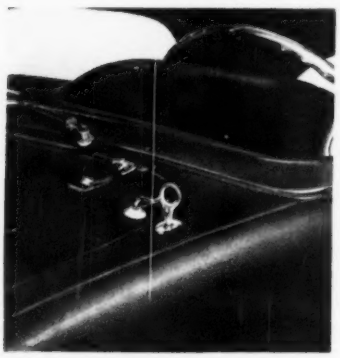
One of the many difficult problems that have to be faced in designing a body for a large vehicle is to make it light in appearance. In this respect, the Cadillac Starlight II is perhaps one of the most successful of Pinin Farina's ventures in recent years. Its success is undoubtedly due to intelligent treatment of the vehicle as an entity: the blending of the sides, front and rear ends has been so successfully achieved that, no matter where one stands to view the vehicle, the lines flow harmoniously into one another.

At the front, horizontal features are accentuated by means of a light grille, the overhang of the panel immediately above it, and an unusual section for the bumper. The grille is approximately 7½ in deep and it comprises eight horizontally mounted steel plates, which are chromium plated. An unusual feature is that the dimension of the plates, between their leading and trailing edges, is 3½ in; this is uncommonly large but gives a very neat, well finished appearance to the grille. The overhung leading edge of the bonnet is in line with the centres of the side-by-side pairs of headlamps, and further continuity of this line is afforded by the pressed line on each side, extending from the extreme front to the rear of the vehicle. Below each twin headlamp installation there is a direction indicator lamp of elongated rectangular form, the frosted white glass of which has two horizontal ribs to harmonize with the grille.

The treatment of bonnet tops for such wide vehicles is not easy and, in this instance, the problem is perhaps further complicated by the twin side-by-side headlamp installation on each side. The wing panel sweeps inwards fairly sharply as it rises from the horizontal line that extends along the side of the vehicle. In fact, it follows fairly closely the radius of the outer lamp. Inboard of each pair of lamps the panel again follows the radius of the inner lamp fairly closely as it drops down to the bonnet surround, where a sharp line is pressed in the panel to mark the junction between the wing and the bonnet surround. This construction has kept to a minimum the width of the wing crown. Apart from the Cadillac motif on the front of the bonnet, the remainder of the panelling between the wings is plain.

A noteworthy feature of the vehicle is the treatment of the sides of the body. Beneath the waist there is the horizontal line, already mentioned, and a second line is formed below it, by the lower edge of a re-entrant curvature of the panel. This second line extends from the top of the front wheel opening to the top of the rear one, falling as it goes, to flow into the trailing end of the latter opening. It is particularly useful in giving a sense of unity between the two wheel openings. In overall appearance, these two lines, together with the re-entrant shape of the panelling between them, give an effect not unlike the *lancéolé* treatment used on some of Pinin Farina's earlier models. Elegant door handles of the push button type are employed and they are styled to harmonize with the overall theme of the body styling.

Above the waist, an unusually light effect has been obtained by various devices, which include the use of a deep windscreen curved in three dimensions, the judicious combination of black and chromium plate on the cant and head rails, and the employment of a transparent roof panel. In addition, the door shut pillar terminates at the waist-line, and, therefore, there is no interruption of the horizontal features at this point; the effect is further enhanced by the tapering cantilever shape of the cant rail, which has its slenderest portion at the front and thickest at the rear. This structure is supported on each side at the front by the slender windscreen pillars with light chromium plated cappings. The treatment of these pillars is unusual in that there is a sharp radius of curvature at their lower ends where they join the door hinge pillar. It would appear that this device has been adopted in order to obtain a steep rake on the screen pillar, without bringing the head rail too far back.



Above, right: Pinin Farina Ferrari, with transparent headlamp fairings. Left: Details of the bonnet retaining strap and spring-loaded steady fixture on one side of the same custom-built car

To protect the occupants from strong sunshine, there is a screen which, when not required, can be retracted from beneath the transparent roof panel into the tonneau. This screen is divided transversely into four sections, or slats, the ends of which are supported in horizontal guide channels in the cant rails. The retraction mechanism is simply a flexible cable and pulley device. To accommodate the four slats there are four guide channels, one above the other, in each cant rail; each is of different length, the lowest being the shortest. The forward ends of these channels form stops to locate the four slats when they are pulled up into position. When the screen is stowed, a hinged flap conceals it.

The rear end treatment of the body echoes that of the front end. Horizontal features are accentuated by the lines of the overhung trailing edge of the boot lid, and by the shape of the bumper; this latter component is of similar section to that at the front, and is wrapped round the sides. A single transparent plastics moulding covers the rear lamp assembly on each side, and it is steeply raked forwards, a chromium plated bezel accentuating the rake. As at the front, there is a sharp demarcation between the wings and the panelling between them.

A noteworthy feature of the interior of the car is the simplicity of the dash treatment. The general arrangement can be seen from the accompanying illustration. Horizontal instruments, of the form most commonly employed in America, are installed, and they are deeply recessed so that there is no danger of reflections on the screen. To the right of the instrument panel is the clock, below this the ignition switch, and to the left of the panel is the cruise control unit, with the lamp switch assembly below it—all the lamps are controlled by a single knob. Immediately below the instrument panel, and flanking the steering column, are two controls, one on each side, for the heater and air conditioning units. The control for the cooling unit is on the left, and

that for the heater and demister unit is on the right. In this connection, it is of interest to note that, in some of the hotter parts of America, refrigeration equipment is regarded as virtually essential, and a high proportion of customers demand it as extra equipment on their vehicles. The two outlets for the air conditioning equipment are arranged one at each side of the dash and take the form of circular discharge nozzles, each of which is louvred and can be rotated to give directional control over the outgoing air.

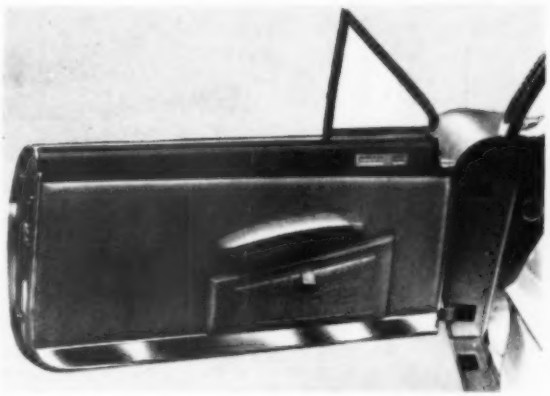
To avoid spoiling the appearance of the facia, the cigarette lighter is concealed beneath a pivoted panel, immediately to the right of the group of instruments; and to the right of this there is a glove box with a lockable lid—the device of concealing untidy controls might be more widely adopted—the facia is trimmed with black hide, and it has a central chromium plated portion extending horizontally to the right of the instrument group. Similar styling treatment has been adopted for the steering wheel; it has a chromium plated two-spoke central assembly, and the upper and lower portions of its periphery are trimmed in black hide; the two sections of the periphery on each side are trimmed with light brown hide the colour of which matches that of the seats.

As can be seen from the accompanying illustration, the treatment of the door trim is unusual. The waist rail is covered with black hide and, below it, the trim panel is faced with brown hide to match the seats. This panel is completely plain except for a chromium plated kick-shield along the base. There is an armrest on the panel, with a pull-up door-release lever extending forward from it. Since the windows are electrically actuated, this is the only manual control, and its neat installation in line with the armrest gives an exceptionally tidy arrangement. The switches for the electric controls are near the front ends of the waist rails of the doors. Below each armrest is a pocket, which is mounted on the trim. It comprises a frame $1\frac{1}{4}$ in deep at its upper end and 1 in deep at its lower end. The elastically tensioned pocket is fitted in this frame.

Another of Pinin Farina's new models is the Alfa Romeo 3500 Super Sport. Aerodynamic principles have been applied in the design, and in this respect a clean front end is important. Among the interesting features is the treatment of the transparent fairings for the headlamps. They are of elongated form, as can be seen from the illustration and, unlike so many of those of other coachbuilders, blend well with the general shape of the wing. Their outboard lower edges, on each side, are aligned with the pressed line that extends from the front to rear below the waist of the vehicle, and their inboard lower edges are aligned with the fairly sharply defined pressed line at the junction between the wings and the bonnet surround. At the rear end of each front wing, where it joins the scuttle, there is an air outlet to allow free passage of air past the brakes and tyres. There is another air inlet at the front end of each rear quarter panel: this also is to cool the brakes and tyres.

Entry and exit to such a low-built car would be difficult were it not for the fact that the portion of the transparent roof that is above the seat on each side can be slid back on guide rails beneath the rear portion. Nylon rollers are employed for the slide mechanism: in the central guide rail there are two of these rollers, one at the front and one at the rear of the sliding panel; while in the guide rail on each side, there is one at the trailing end of the sliding portion. When each of the two sliding portions is in the forward position, it is located by a tongue on the leading edge at its outboard side, and a slot in the head rail, and by a small spring-loaded catch at the leading edge near the centre.

The dash treatment is interesting in that the large diameter, easily read, engine speed indicator and the speedometer are to the left, while all the smaller diameter dials are in the shallower portion of the facia above the steering column. From right to left the instruments are:



No matter from what aspect the Cadillac Starlight II is viewed the lines of its sides and front and rear ends blend harmoniously. Above: Simplicity is the keynote of the styling of the door trim panel of the vehicle

The long sleek appearance of the Pinin Farina Cadillac Starlight II is enhanced by the employment of a cantilever shape cant rail. Below: Circular, louvred air conditioning vents are under each end of the dash facia

the fuel contents gauge, water temperature thermometer, oil temperature gauge, oil pressure gauge, and a second fuel contents gauge, which is necessary because there are two tanks, one behind each rear wheel arch in the boot.

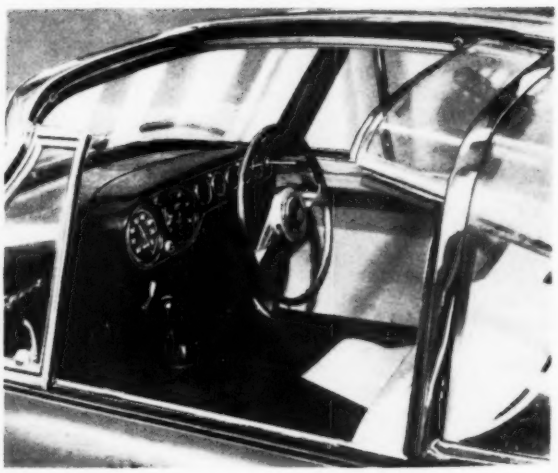
There are one or two interesting details on the Pinin Farina 400 Super Ferrari. This model, too, is well streamlined, but it is a drop-head sports coupé. The headlamps are behind transparent plastics fairings. The line of the lower edge of the fairing on the outside is a continuation of the line pressed along the side of the body and of the line of the top of the wing opening. The lower edges on the inner sides of the fairings blend, as on the Alfa Romeo, with the junction between the wings and bonnet surround. An unusual feature for a modern car is the securing of the bonnet lid by means of leather straps. As can be seen from the accompanying illustration, the lid is prevented from rattling by a spring-loaded retainer device on each side.

Vignale

One of the interesting vehicles made recently by Vignale is the Fiat 1500 fixed-head coupé. The front end styling is a development of the wrap-round grille theme which has been popular for several years on American cars, and more

The two views above are of the Vignale Fiat 1500. A noteworthy feature is the continuation of the horizontal lines of the grille around the sides of the vehicle. Left: On the Pinin Farina Alfa-Romeo there is an air outlet adjacent to the scuttle, and an inlet on the rear quarter panel, for ventilation of the brakes

Right: The Pinin Farina Alfa-Romeo is of particularly well streamlined form. Below, right: Details of the dash layout and arrangement of the sliding head on each side of this same Pinin Farina model, left, black and white in contrast are used to accentuate the horizontal features on the facia of the Vignale Fiat 1500



recently on some of the European ones. On this vehicle, however, the arrangement is different in that the grille itself, which comprises three chromium plated horizontal bars with a vertical central pillar, extends only to a point just inboard of each side of the vehicle. The wrap round extension is formed by pressed sections continuing the lines of the top and bottom frames of the grille opening round the sides of the wing panels. As can be seen from the accompanying illustrations, these pressed sections extend back to the front edge of the wheel openings. Both the front and rear bumpers are styled to harmonize with the shape of the pressed sections above and below the grille. On each side of the vehicle a line, extending from the extreme front end to within an inch or two of the rear, is formed by an obtuse re-entrant angle pressed in the panels. The styling of the dash is of interest in that black and white are used in contrast to accentuate horizontal features. The method employed can be seen in the illustration. Where the white section houses the two instruments it is deep, but it becomes very shallow as it extends across to the extreme side of the vehicle.

Fifty Years of Component Manufacture

IN THE special issue of *Automobile Engineer*, in June, celebrating the fiftieth anniversary of our first publication, so much of the available space was taken up with the history of the development of vehicles and their manufacturers that there was little room left for anything about the extremely important part played by the accessory and component suppliers. To cover even a representative selection of all these would occupy the whole of another issue, which is impracticable. However, we feel that readers will be interested in brief details of those who have celebrated their Jubilees during recent months.

This year marks the fiftieth anniversary of the foundation of The A.P.V. Co. Ltd., one of the leading specialists in the production of welded vessels of aluminium and stainless steel. The company was established in Wandsworth, London, in June 1910 and moved to its present site at Crawley, Sussex, about 4½ years ago. Although primarily associated with the dairy, food processing, brewing and soft drinks industries, A.P.V. was a pioneer of aluminium tanks for the bulk transport of liquids by road. The production of vehicle tanks of aluminium and stainless steel continues to form a substantial part of the company's activities.

Another company to have been in existence for 50 years is Armstrong Patents Ltd., of Beverley, Yorks, best known in connection with suspension dampers. The early years were devoted mainly to general garage work, but Gordon Armstrong, the founder, at one time put into production a light two-seat car known as the Gordon, which incorporated a number of advanced ideas. It was not until the 1920s that the company's interests first extended to suspension dampers, and the initial production order for such components was received towards the end of that decade.

Armstrong's post-war expansion has been considerable. Not only has a second factory been opened at York, but others have been established in Canada and Australia, and the group employs over 3,000 people. Dampers made by the company are now fitted to railway rolling stock as well as to most types of road vehicle, and another important product is the Heli-Coil thread insert.

Although the history of the Solex carburettor actually began in 1908, it was not until June 1910 that the trade name was registered in France, where the original instrument was designed and patented. Solex carburettors were first imported into Britain in 1912; the importing of complete instruments continued until the early 1920s, from which time an increasing amount of manufacture was carried out at the factory in Marylebone Road, London. By 1928 they were entirely manufactured in this country.

To cope with the increasing demand after the second World War, Solex Ltd. built a second factory in south-east London about 2½ years ago. By mid-1959, this factory was producing 7,500 units a week, and the output is now nearly double that figure. In addition to the factories in England, there are others in Europe and one in Australia; the combined production last year amounted to more than three million carburettors.

An even older company is Lake and Elliot Ltd., of Braintree, Essex, well known for its iron and steel castings. W. B. Lake opened a cycle shop in Braintree in 1892, and soon began to manufacture tool kits. Four years later he went into partnership with E. F. Elliot, and the range of products was extended to include cycle accessories and jacks for the motor trade. In 1905, an iron foundry was built, and one for steel followed during the next year. The business was incorporated as a limited liability company in 1910, when the first electric furnace in Great Britain was installed in the factory, for the production of steel castings.

During World War I, a large tonnage of castings was produced for all service departments; the output included naval armour plate and components for guns and vehicles. After the war, the foundries were extended and an additional factory, built originally for the mass production of fuses, was converted to the manufacture of jacks. The company supplied its first hydraulic jacks to the motor industry in 1923. Five years later, it introduced cast iron brake drums for vehicles; at about the same time, a high-frequency electric furnace was installed for the production of special alloy castings.

For the period 1939 to 1940, Mr. Lake was President of the Institute of British Foundrymen, and during the second World War, the company succeeded in doubling the tonnage output of its foundries. Castings were produced for tanks, ships, aircraft, guns and military vehicles. In addition, jacks were supplied for tanks and other fighting vehicles, as well as for aircraft maintenance and A.R.P. rescue purposes.

A post-war event of importance was the taking out in 1950 of a licence to manufacture the American Millenium Key refinery fittings; this type of work was actually first undertaken by the company as far back as 1928. In 1955, The National Steel Foundry (1914) Ltd., of Leven, Fife, was purchased and became a subsidiary. During the next year, the steel foundry was further extended, with the opening of a new unit for special alloys.—*To be continued.*

Flame-Retardant Foam Plastics

RECENTLY, a flame-retardant polyether foam for upholstery has been introduced by Aeropreen Products Ltd, of High Wycombe, Bucks. It should significantly reduce the risk of fire arising from, for example, dropped cigarette ends and unextinguished matches. In it, a flame-retardant intermediate ingredient is incorporated as part of the molecular structure of the foam. This ingredient does not affect any of the physical performance characteristics such as the compression set and tensile strength of the foam materials.

Thermal Aspects of Vehicle Braking

(CONTINUED FROM PAGE 295)

Part 11: Temperatures Attained Under Various Conditions of Vehicle Operation

T. P. NEWCOMB, M.Sc., A.Inst.P

IF, with repeated braking, the inter-braking periods are more than a few seconds in duration, the contacting bodies of the brake assembly are virtually at uniform temperatures before each new brake application. Although only a small fraction of the heat generated in a given braking period is lost during that period, radiation, conduction and convection losses persist indefinitely after brake release until the whole of the heat generated is ultimately lost to the atmosphere. However, unless temperatures above 500-600 deg C are reached, radiation losses are negligible. Such temperatures are unlikely unless isolated local hot spots are formed or very violent brake applications are made. Heat is lost from the drum by conduction to the flange on the axle to which the drum is attached and thence to the wheel hub cap. In a well ventilated brake with a small hub cap—termed an open brake, Fig. 13—conduction losses to the hub are small and the principal method of heat transfer is by convection directly to the atmosphere.

If heat is lost to the atmosphere by convection then, during a series of identical stops made at regular intervals, the temperature of both the drum and the lining plus shoe at any stage can be calculated. Odier[15] and Fazekas[16] both derive the following equation giving the temperature after the nth application in the form

$$\theta_n'' = \theta_a + \Delta\theta \left\{ \frac{1 - exp(-nbt_a)}{1 - exp(-bt_a)} \right\} \quad \ldots\ldots (19)$$

where θ_a = temperature of surrounding air
θ'' = average temperature of the body, considered after braking
$\Delta\theta$ = increase in average temperature during a single brake application
t_a = time interval between applications
$b = Ah/WC$ and for the body considered
A = exposed area
W = weight
h = coefficient of heat transfer
C = specific heat

If braking continues long enough $_{exp}(-nbt_a)$ tend to zero and θ_n'' approaches a limiting temperature θ''_{limit}, where

$$\theta''_{limit} = \theta_a + \frac{\Delta\theta}{(1 - exp(-bt_a))} \quad \ldots\ldots (20)$$

In general bt_a is small and a good approximation to equation (20) is

$$\theta''_{limit} = \theta_a + \frac{\Delta\theta}{bt_a} \quad \ldots\ldots (21)$$

Experimental verification of these equations has been made by Newcomb[8], for drum and disc brakes mounted on an inertia dynamometer and cooled with a fan, and also for the brake linings of an automobile repeatedly braked on a level track.

If $\Delta\theta$, determined from equation (13), and b are substituted into equation (21), then for the front drum when repeatedly braked to rest

$$\theta''_{limit} = \theta_a + \frac{\sigma y P u^2}{4gfA_1 ht_a} \quad \ldots\ldots (22)$$

where h, the heat transfer coefficient, can be determined experimentally by measuring the rate of cooling when the vehicle is running under conditions similar to those during braking. For design purposes, an estimate of h for a well ventilated front drum can be made from the expression

$$h = \frac{2V^{0.6}}{10^3 D^{0.4}} \quad \ldots\ldots (23)$$

where V is the air velocity past the drum and D is its external diameter.

With the rear drums, owing to shrouding by the vehicle, the value of h is approximately half that of the front drums.

The limiting temperature of front lining and shoe is given by

$$\theta''_{limit} = \theta_a + \frac{(1 - \sigma)\, yPu^2}{8gfA_1 ht_a} \quad \ldots\ldots (24)$$

and if a limiting temperature be imposed on the linings for given energy conditions of braking, equation (24) can be used for the calculation of A_1.

If a vehicle is braked only to a velocity U that is a fraction of the initial velocity u, and it is then accelerated back to the original velocity in a regular cycle of time t_a, the limiting temperatures corresponding to equations (21) and (24) are

$$\theta''_{limit} = \theta_a + \frac{\sigma y P (u^2 - U^2)}{4gfA_1 ht_a} \quad \ldots\ldots (25)$$

for the front drum and

$$\theta''_{limit} = \theta_a + \frac{(1 - \sigma)\, yP (u^2 - U^2)}{8gfA_1 ht_a} \quad \ldots\ldots (26)$$

for a lining plus shoe.

With a badly ventilated brake drum, that is a drum well shrouded in a wheel, with small air inlets from the exterior

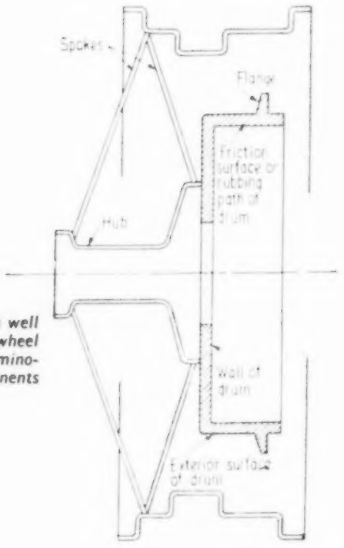


Fig. 13. Cross section of a well ventilated brake drum and wheel assembly, showing the terminology adopted for the components

of the wheel to the outside of the drum, heat is generated in the brake drum and is then conducted to the metal portion of the hub and wheel, and eventually is lost to the atmosphere by convection. If the mass of the hub and wheel is W'' and that of the drum is W, both having specific heats C' and C respectively, then after a single brake application, the overall rise in average temperature of the drum and surrounding metal is

$$\Delta\theta = \frac{\sigma y P u^2}{4gJ(WC + W''C')} \qquad (27)$$

and

$$\theta''_{limit} = \theta_o + \frac{\sigma y P u^2}{4gJA'h't_o} \qquad (28)$$

where A' is the overall area exposed to convection and h' the overall coefficient of heat transfer. These values are at present unavailable.

From these equations it can be seen that the temperature of the drum and lining plus shoe during braking at regular intervals depends mainly on the following factors:

(i) The initial energy of the vehicle $\frac{1}{2}Pu^2/g$

(ii) The coefficient of heat transfer, which has a considerable influence on the temperatures attained and which, for the drum, depends on whether the surface is exposed to a stream of air. In a well ventilated drum that is cooled by a turbulent air flow, the coefficient of heat transfer is proportional to $V^{0.6}$. For a drum shrouded by the wheel the coefficient of heat transfer is practically constant or, at the most, proportional to a low power of the air velocity. The cooling coefficient of the linings plus shoes is virtually the same whether the drum is ventilated or shrouded

(iii) The thermal capacity WC of brake drum or lining plus shoe for, although equations (21) and (24) show that the limiting temperature attained is independent of this term, equation (19) contains it and consequently an increase in value of WC, that is, a decrease in value of b, causes a reduction in the rate of increase in average temperature. As an example, consider a high power car being repeatedly braked from 45 m.p.h. to rest in 5 sec, the vehicle having cast iron drums of thicknesses $1\frac{1}{8}$ in, $\frac{1}{4}$ in and $\frac{3}{8}$ in and being equipped with a bimetallic drum of equivalent weight to a cast iron drum of thickness $\frac{1}{4}$ in. If they are braked at the same time cycle $t_o = 30$ sec and the value of b is 0·005 for the cast iron drum of thickness $\frac{1}{4}$ in, then $b = 0{\cdot}0067$ and 0·00375 for the cast iron drums of thicknesses $\frac{3}{16}$ in and $\frac{3}{8}$ in respectively. In a bimetallic drum, the value of its specific heat C is 0·19, compared with 0·136 for cast iron; consequently, for the same drum weight, b is 0·716 times the value of a cast iron drum. Fig. 15 shows the variation of $\theta_n'' - \theta_o$ with number of brake applications for all these drums at the front. These curves indicate that the rate of increase in average temperature can be reduced by using a thicker brake drum or, alternatively, by using a bimetallic drum and so avoiding a change in drum weight. All the drums eventually attain the same limiting temperature

(iv) The term σ, which is the proportion of the total heat generated that enters the drum, depends on the thermal properties and areas of the contacting bodies. For conventional asbestos-resin friction materials having an arc of lining between 90 deg and 120 deg —which is usual practice to obtain economical use of the lining—σ changes little from 0·95

(v) The term y, which may change when the car is fully laden with passengers and luggage

(vi) The temperature θ_o surrounding the drum, which depends on ventilation, as well as ambient temperature

(vii) The time t_o between brake applications, if t_o decreases then the limiting temperature increases and more brake applications are required before the contacting bodies reach a stable temperature.

Similar equations apply to a brake disc and pad during repeated braking. In the case of a disc made of the same material and having twice the thickness of and the same rubbing path area as a drum, the most important alteration in the previous equations giving θ_n'' is that b changes because of the greater area exposed to the atmosphere by a disc, as compared with that of a drum. In a typical disc brake for a car eight-ninths of the disc surface is exposed to the atmosphere and if b is the value for a drum then $16b/9$ is the corresponding value for the disc, that is, $b = 0{\cdot}009$ for a disc whereas $b = 0{\cdot}005$ for a $\frac{1}{4}$ in thick drum. If this disc brake is used on the high power car considered previously, and braked under the same conditions, then the variation of $\theta_n'' - \theta_o$ with n is as shown in Fig. 15. This curve illustrates the more rapid build-up of temperature of a disc, as compared with that of a drum, and also shows that they both reach a similar limiting temperature.

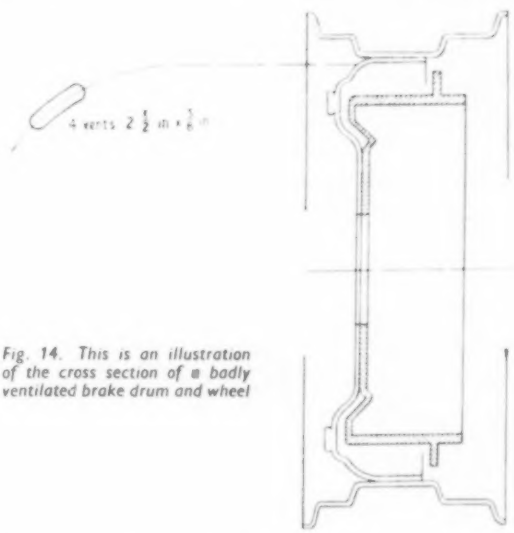
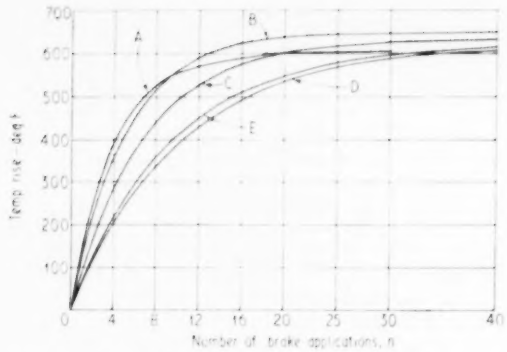


Fig. 14. This is an illustration of the cross section of a badly ventilated brake drum and wheel

Braking on a circuit

The analysis already outlined only applies to regular repeated braking on a level track such as is commonly used in manufacturers' fade tests but, except in unusual circumstances, is not experienced in general motoring. However, if the most severe conditions, that is, the greatest energies dissipated in the shortest interval of time, that are likely to be encountered in service can be reduced to a regular cycle of braking, such cyclic tests can be used to determine the suitability of a vehicle braking in normal road usage. Also, standardized tests are more convenient and reproducible, and enable the brake assembly to be proved under known conditions. Brake usage in general will now be discussed.

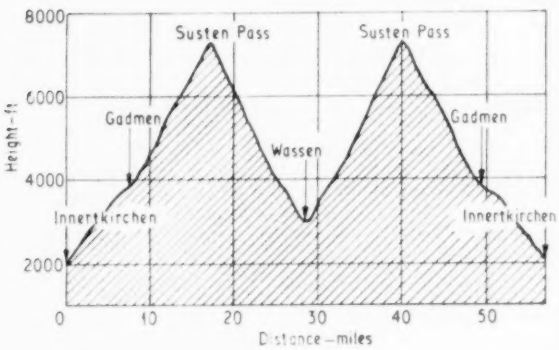
Carpenter[17] and Carpenter and Lees[18] investigated a number of important variables in brake usage. Equipment was installed in cars, to record the speed of revolution and angular deceleration of the brake drums, together with the energy dissipated at the four brakes. The rate of working at the brakes is proportional to the mean brake torque multiplied by the drum speed and was directly measured by electrical apparatus so that any error due to wheel slip was eliminated. Corrections were made to account for the energy loss due to drag. Characteristics of braking behaviour were observed for two cars when run over country, hill and mountain circuits. Heights at various



A ½ in thick disc; **B** ½ in thick cast iron drum; **C** ½ in thick cast iron drum; **D** ½ in thick cast iron drum; **E** bimetallic drum of weight equivalent to that of the ½ in thick cast iron drum

Fig. 15. Comparison of the average temperatures of different brake drums during repeated applications to reduce the speed from 30 m.p.h. to zero in 5 sec, at a frequency of two applications per minute. The coefficient of heat transfer and the area of the rubbing path are the same in all cases; details of the drums and discs are given in the key

Fig. 16. This is a diagram representing the profile of the Alpine circuit



distances along these circuits are represented in Figs. 21, 22 and 16 respectively. The vehicles selected were a saloon car of laden weight 32 cwt and a sports car of laden weight 23 cwt, both having similar engine power; road holding and other factors were maintained constant, so far as possible, to obviate variations in road-tyre losses. Only the sports car was run over the mountain circuit.

In Fig. 17, taken from Carpenter and Lees[18], it can be seen how the energy dissipated at the brakes varies with mean speed of the vehicles on the hill and Alpine circuit. These curves show that $W_m = KV_m^n$ where W_m is the work done, V_m is the mean journey speed, K a constant and n is also constant for a particular type of driving. On the hill circuit much more work was done by the brakes of the saloon car, on account of its heavier weight. The results are striking, however, for although the saloon car only weighs 1·35 times that of the sports car, the work done increased in the ratio 4:1. Comparing the results for the sports car on the Alpine and hill circuits, as shown in Fig. 17, it can be seen that the line obtained from the Alpine results is much steeper than that obtained from the hill circuit. Thus, to increase the mean speed on the Alpine circuit entails a much greater increase in the work done at the brakes than would be required for the same change on the hill circuit.

The number of brake applications per mile is plotted against the mean journey speed in Fig. 18. It can be seen that the number of brake applications per mile is independent of the vehicle used and of the driver, but depends on

TABLE 2—Work done by brakes in different stages of the journey

Stage of Journey	*Work done, ft-lb*
Chapel-en-le-Frith to Glossop, distance 0-9 miles, 18 applications	1,352,450
Snake Pass to Hathersage, distance 9-27·5 miles, 21 applications	2,479,083
Hathersage to Castleton, distance 27·5-40·1 miles, 16 applications	1,868,157
Castleton to Chapel-en-le-Frith, distance 40·1-49·9 miles, 10 applications	1,203,035
Total	6,902,725

the terrain. The Alpine circuit is again more arduous than the hill circuit and, in fact, no mean speeds above 36 m.p.h. were recorded on the Alpine route due partly to greater traffic density and partly to difficulties of acceleration and braking rapidly enough to maintain higher mean speeds. If the mean speed was dropped to approximately 25 m.p.h. the number of applications per mile was the same for both circuits.

Shown in Fig. 19 are the cumulative frequency diagrams for mean rate of working, work done per stop and maximum deceleration when the saloon car was driven over the hill circuit at a range of speeds. From Fig. 19a, which shows the distribution of the energy dissipated per stop, it can be seen that although nearly half the brake applications recorded dissipated less than 50,000 ft-lb, in some cases 25 times this amount of work was done in a single application. In Fig. 19b are demonstrated the mean and maximum rates of working during the brake applications. The mean rate of working most frequently occurs in the lower end of the range from 10 to 40 b.h.p. Furthermore, the maximum power output of the engine of the car is 100 b.h.p. and the highest value of mean rate of working at the brakes was 114 b.h.p. The ranges of maximum and mean deceleration recorded are shown in Fig. 19c. From this it can be seen that the maximum deceleration never exceeded 0·5 g and was generally between 0·05 g to 0·15 g during approximately 3,000 brake applications made in 1,400 miles of driving. The mean deceleration histogram demonstrates that, during a substantial number of brake applications, little or no deceleration was recorded. These represent the case where the speed of the vehicle was controlled, rather than reduced, on gradients.

In the above investigation no temperature measurements were made, but recently some measurements have been made of the temperatures of linings of another automobile when operated over the hill and country circuits. The car plus three passengers weighed 2,716 lb and was fitted with two-leading-shoe type front and leading-and-trailing-shoe type rear brakes, all rubbing paths being equal on each wheel. Copper-constantan thermocouples were inserted in each of the eight linings and connected to temperature meters mounted in a panel and photographed with a cine-camera, Fig. 20. Also on the panel were two counters, which recorded the number of brake applications. The camera could be operated by a switch which, when pressed, brought a relay into action and provided illumination for 0·5 sec during which time a photograph was taken of the temperature increase corresponding to the brake application. Hence, after a brake application, the temperatures could be recorded when the linings attained their maximum temperature which generally occurred between five and ten sec after braking.

Shown in Fig. 21 are the temperatures attained in the front and rear linings at the various mileages at which braking occurred on the hill circuit, and also the heights

above sea level, corresponding to various stages of the route. It can be seen that there is a marked difference between brake usage up to Glossop and from the Snake Pass up to Ladybower bridge. However, the heaviest brake applications occurred between Hathersage and Grindleford. Prior to Glossop, despite the gradients, braking was restricted to frequent short applications on the corners and consequently the temperatures were not very high until applications were made in the speed restricted zones in the town of Glossop itself. Down Snake Pass after a few initial heavy brake application, owing to the rather straight open road in this area, the linings remained at a fairly high uniform temperature. The next, and highest temperatures reached over the whole journey, were concentrated in descending from Hathersage to Grindleford and were due to heavy application required at some of the bends in this region. Over the whole circuit the average speed was 36·8 m.p.h, and 65 brake applications were made. The average number of applications per mile was 1·30, which is rather lower than that generally quoted for normal road usage. An analysis of the work done by the brakes at various stages of the journey is given in Table 2.

The total work done was 6,902,725 ft-lb, and its thermal equivalent is 8,872 B.Th.U, of which only 66 goes to each front lining and 44 to each rear lining. During the whole time of operation round the circuit the heat lost by the linings is 19·6 B.Th.U. and the net heat given to the front linings is 46·4 B.Th.U, which gives an average temperature over the circuit of 212 deg F, as compared with approximately 180 deg F obtained from the graph.

On the flat country circuit the overall work done is much less than the hill circuit, and Fig. 22 shows the variation of temperature of the front and rear linings at different locations on the route. This graph indicates that no violent brake applications and little variation in temperature occurred, as would be expected. The temperatures experienced on this vehicle showed a difference between front and rear linings, which is due to the high value of y and to the fact that both drums are well ventilated. In most vehicles, however, the front and rear drums reach the same temperature because the high value of y for the front drums is compensated for by their better ventilation.

This Derbyshire hill circuit is perhaps of sufficient severity to cater for most conditions likely to be experienced in this country. The Alpine results show that, on the Continent, much more severe applications are encountered: the most severe region on the Alpine circuit was the Susten Pass where, during the descent at 36 m.p.h. mean journey speed, 47 brake applications occurred in 6·44 min, giving an average of 12 applications per mile. From data communicated by Dr. Carpenter, it was found that the maximum energy dissipated in a single application was 183,000 ft-lb; the majority of applications involved approximately one-sixth of this energy and the total energy dissipated descending the pass was 2×10^6 ft-lb. For a car weighing 2,600 lb the equivalent fade test to dissipate the same total energy would be 12 brake applications, from 46 m.p.h. to rest, at a deceleration of 0·5 g at 30 sec intervals. During each brake

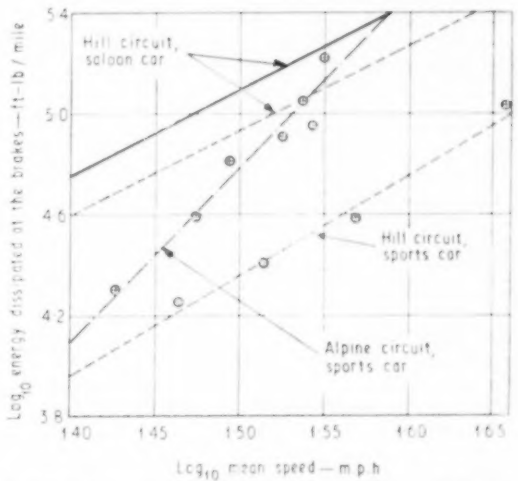

Hill circuit, saloon car
Hill circuit, sports car
Alpine circuit, sports car
Log10 energy dissipated at the brakes—ft-lb / mile
Log10 mean speed—m.p.h

Fig. 17. Effect of terrain and type of vehicle on the energy dissipation

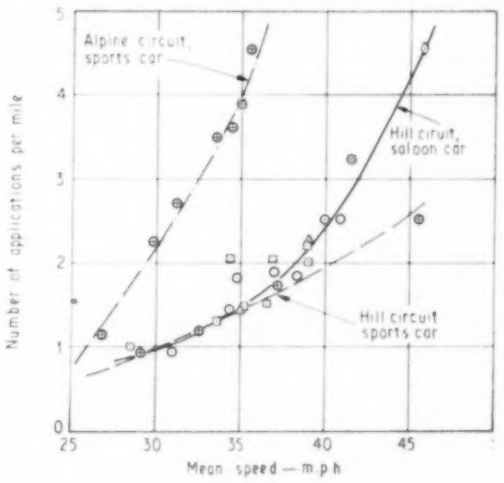
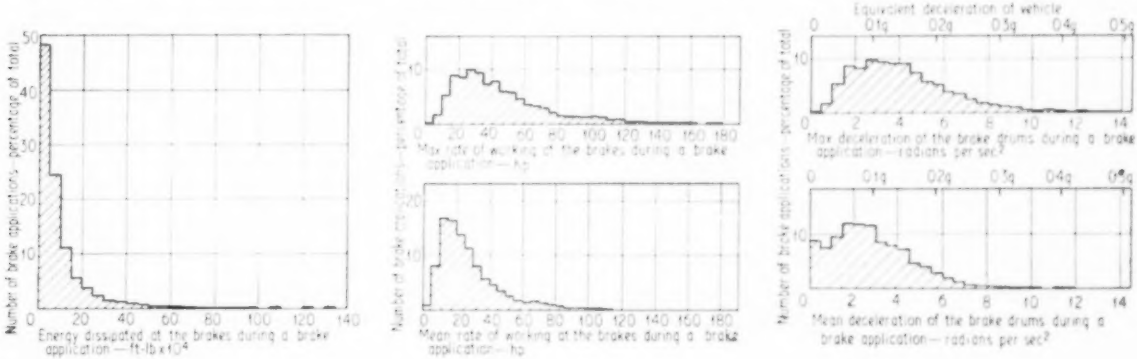


Fig. 18. The effect of the mean speed on brake applications per mile

Fig. 19. Frequency distribution diagrams[19] for 1,400 miles driving, with a total of 2,800 brake applications, in the saloon car on the hill circuit


Number of brake applications—percentage of total
Energy dissipated at the brakes during a brake application—ft-lb x 10⁴
Mean rate of working at the brakes during a brake application—hp
Equivalent deceleration of vehicle
Max deceleration at the brake drums during a brake application—radians per sec²
Mean deceleration of the brake drums during a brake application—radians per sec²

application the work done is then the same as that developed in the heaviest brake application experienced on the pass. By this means it is possible to reduce the most severe conditions to regular repeated brake applications on the level. If the mean speed down the pass were increased to another value, say V_m, then the total energy dissipated would be given from the equation $W = KV_m^n$ where K takes the value derived from the 36 m.p.h. journey. Therefore, a new test can be devised, dividing the total energy into 12 applications and determining, in the manner described previously, the energy that has to be dissipated in each brake application.

Patterns of driving behaviour

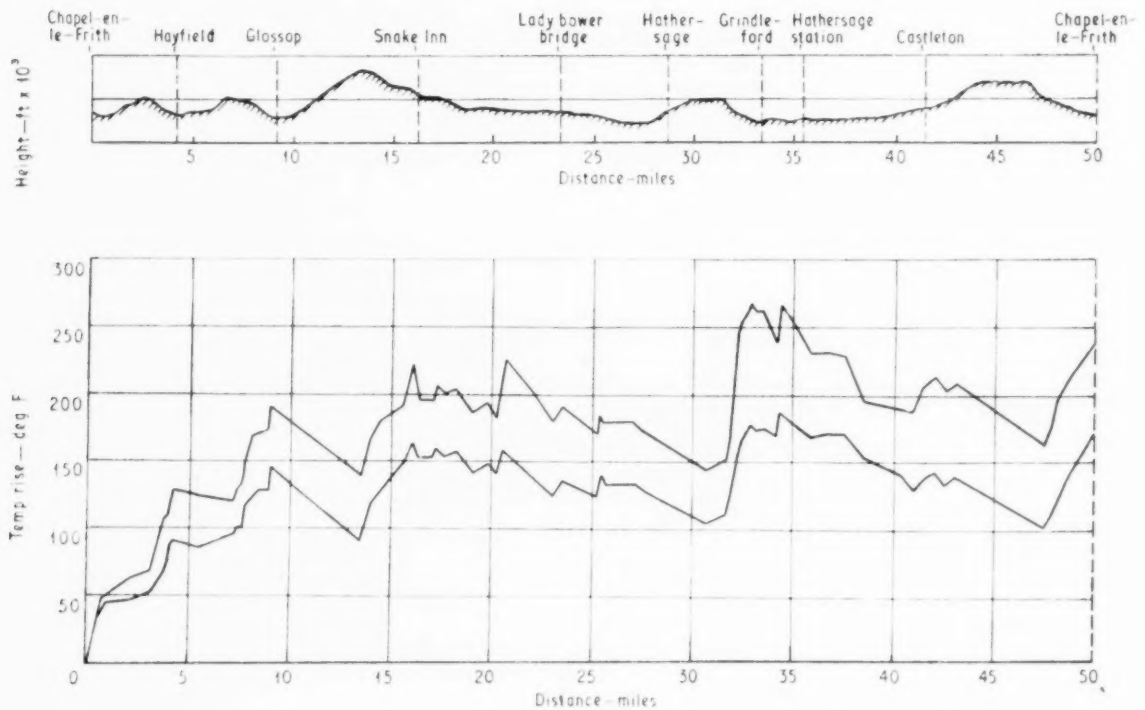
Little information has been published on this subject and most of it is given by Carpenter[17], in his investigation into brake usage. Four drivers were used on the hill circuit and all generally exhibited similar characteristics with regard to the factors recorded in Carpenter's paper. The numerical values of some of these factors fell, however, into two distinct groups, apparently as a characteristic of the driver, as shown by A and B and C and D in Figs. 23 and 24. However, from Fig. 25, the mean rate of working is independent of the driver, yet the kinetic energy lost by the vehicle during brake applications was not materially reduced. Apparently the reduced work done occurs simply by virtue of the shorter braking time, and the unchanged kinetic energy suggests that the total time lost by the vehicle is not reduced. If the same energy is dissipated and less work done by the brakes, then the remaining energy is accounted for by the increased use of the gears to produce engine braking to reduce the initial vehicle speed before the brake pedal was depressed. Drivers A and B both had experience in brake testing, and would not use the engine to spare the brakes. On the other hand, driver C was the owner of a small sports car, and habitually dropped to third gear before braking. The two distinct lines probably represent, therefore, the different habits in respect of changing gear before braking.

Some indication of the combined effect of adverse weather conditions and heavy traffic, are shown in Figs. 26, 27 and 28, but results are not recorded for driving under the worst possible conditions. The results show that some degree of difficulty can be tolerated without increase in the severity of the braking, but beyond this, there is a material increase in the duty imposed upon the brakes.

Brake rating

In the previous analysis, expressions have been given for the temperature rise in single and in regularly repeated applications, and it has also been shown how random braking can be reduced to equivalent cyclic braking. The equations will now be considered in some detail to show how the vehicle designer can readily make use of the results. From the thermal aspect, the main requirement of the designer of the brakes of a given vehicle is to determine what area of braking path is required to withstand the heavy braking likely to be experienced in normal road usage. For an economical brake, it is unlikely that the thermal properties of the drum and linings will differ much from those of steel and asbestos friction materials and consequently the bulk of the heat generated will always be transferred to the brake drum. This means concentrating on the brake drum to produce a reduction in interface temperature. In an individual application, an increase in drum thickness will reduce the maximum temperature reached but also increase both the thermal stresses and the unsprung weight of a vehicle. In the first instance it is essential to choose a drum thickness adequate to resist distortion due to mechanical stresses and possess sufficient thermal capacity for continuous braking. This is of great importance for say the first ten brake applications in a series, when a very rapid build up in temperature can

Fig. 21. Temperature variation, in deg F above ambient, of the brake linings when the brakes are applied normally on a hilly circuit; an average speed of 36·8 m.p.h. was attained for each journey. The upper and lower lines represent the temperatures of the front and rear brake linings respectively



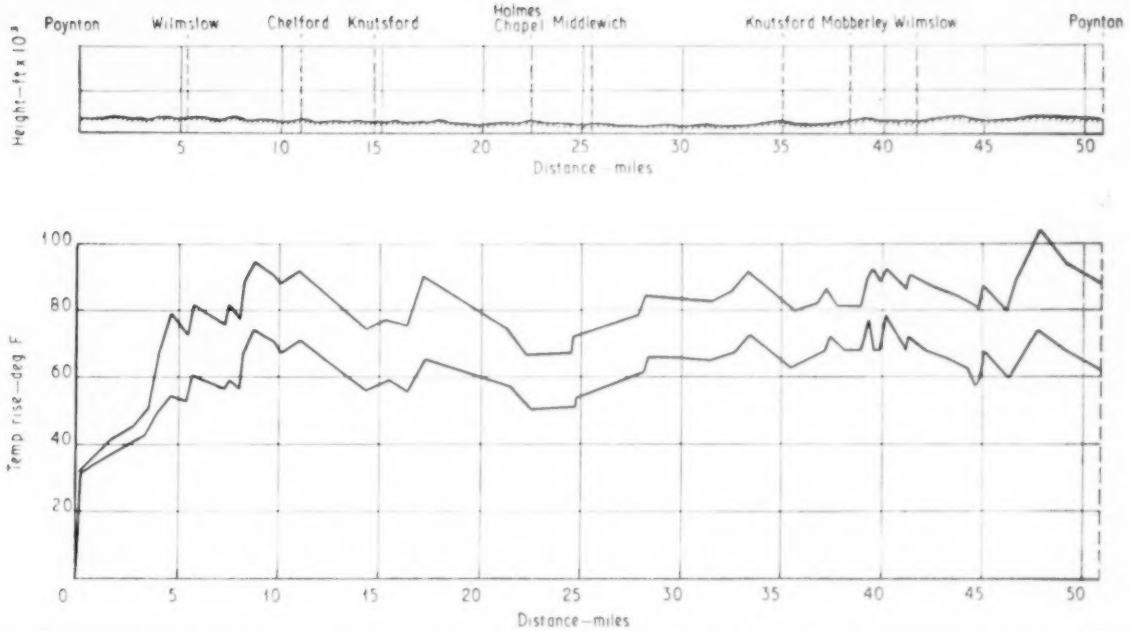


Fig. 22. Curves showing temperature variation, in deg F above ambient, of the brake linings of a car operated on a relatively flat circuit. Of the two, the upper curve represents the temperature variation of the linings in the front brakes, and the lower one is that of the rear linings

result if the drum has insufficient thermal capacity, Fig. 15. For a low power saloon car, a drum thickness of $\frac{3}{16}$ in will suffice, but this will be inadequate for high power saloon cars, for which at least $\frac{1}{4}$ in. thickness is needed. Having decided on an adequate drum thickness, it remains to calculate the area of rubbing path and also make provision for adequate cooling.

To avoid a deterioration in the brake performance of a vehicle, the temperature at the interface of drum and lining during braking must be less than a certain value. During the $(n+1)^{th}$ brake application under conditions of regularly repeated braking, the friction surface temperature is $\theta_n'' + \theta$ and in particular its maximum value θ_s is $\theta''_{limit} + \theta_{max}$, and from Newcomb[1]

$$\theta_s = \theta_o + \frac{\sigma y P u^2}{4gJA_1}\left\{\frac{1}{ht_o} + \frac{\alpha_1}{K_1 d_1} + \frac{7d_1^{.5}}{45K_1\alpha_1 T^2}\right\} \quad \ldots\ldots(29)$$

which reduces to

$$\theta_s = \theta_o + \frac{\sigma y P u^2}{10^5 A_1}\left\{\frac{1}{ht_o} + 1{\cdot}043\right\} \quad \ldots\ldots(30)$$

for a cast iron drum of thickness $\frac{1}{4}$ in, since the last term inside the bracket in equation (29) can be neglected. When repeated braking from 46 m.p.h. to rest occurs

$$\theta_s = \theta_o + \frac{4{\cdot}48\,\sigma y P}{10^2 A_1}\left\{\frac{1}{30h} + 1{\cdot}043\right\} \quad \ldots\ldots(31)$$

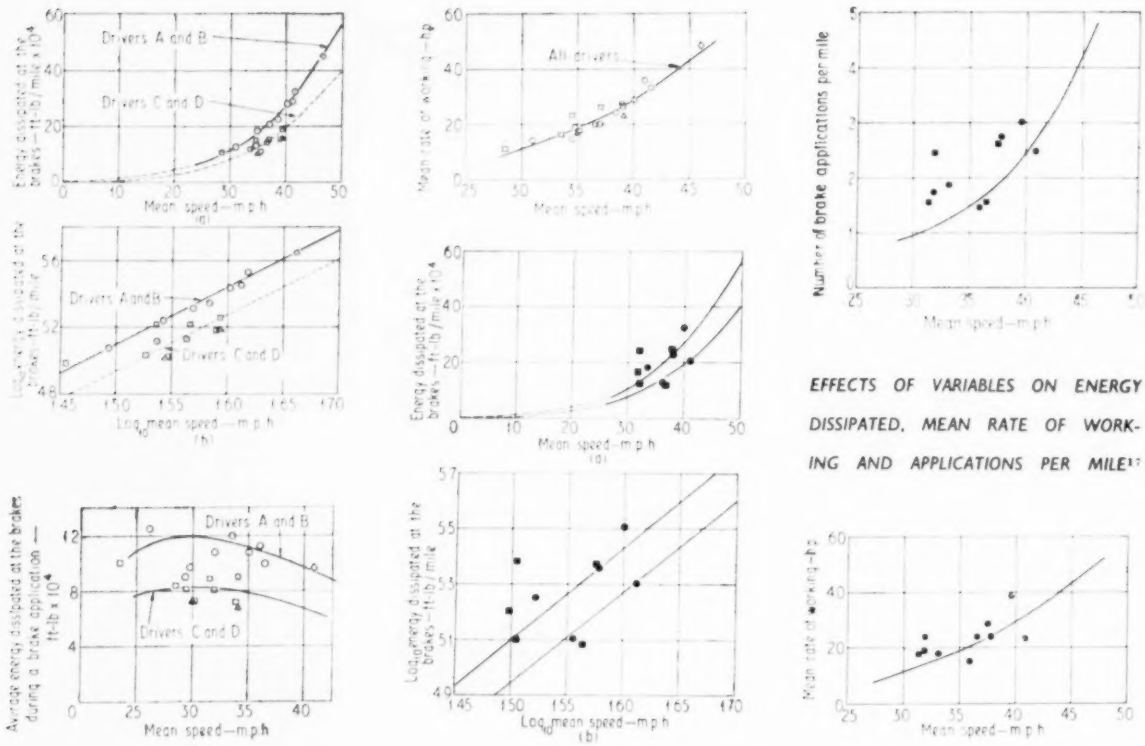
By imposing a limiting θ_s on the drum when braking from a given velocity, time and cooling coefficient, equation (29) enables the minimum value of the rubbing path A_1 to be determined.

The preceding expression is based on repeated braking to rest. If check braking at regular intervals from a velocity u to a velocity U occurs, then the maximum temperature corresponding to equation (31) is

$$\theta_s = \theta_o + \frac{\sigma y P\,(u^2 - U^2)}{10^5 A_1}\left\{\frac{1}{ht_o} + 1{\cdot}043\right\} \quad \ldots\ldots(32)$$

In braking with a cast iron drum, the maximum temperature rise permissible will be taken as 810 deg F (450 deg C). If drum temperatures higher than this were to be encountered, in bonded linings for example, the linings would reach an average temperature greater than 740 deg F, and the bonding agent between lining and shoe might be expected to fail. The maximum temperature permissible for a bimetallic drum would be 680 deg F (380 deg C), because the bond between the aluminium and cast iron would otherwise be endangered. With the value θ_s equal to 810 deg F, $\sigma = 0{\cdot}95$, $y = 0{\cdot}6$ and $h = 0{\cdot}0006$ B.Th.U/ft²-sec, as deter-

Fig. 20. Set-up used for recording photographically the readings on the gauges indicating temperatures and number of brake applications


Drivers A and B
Drivers C and D
Energy dissipated at the brakes—ft-lb/mile x 10⁴
Mean speed—m.p.h
(a)
Log₁₀ energy dissipated at the brakes—ft-lb/mile
Log₁₀ mean speed—m.p.h
(b)
Average energy dissipated at the brakes during a brake application—ft-lb x 10⁴
All drivers
Mean rate of working—hp
Number of brake applications per mile

EFFECTS OF VARIABLES ON ENERGY DISSIPATED, MEAN RATE OF WORKING AND APPLICATIONS PER MILE[17]

Fig. 23, top left. (a) With drivers A and B, the energy dissipated equals the mean speed raised to the power 3·39, while with drivers C and D it equals the mean speed raised to the power 3·29; (b) The same curves plotted on a base of $\log_{10}$ mean speed. Fig. 24, bottom left. Effect of mean speed on the average amount of energy dissipated at the brakes per application. Fig. 25, top centre. The effect of the mean speed on the mean rate of working of the brakes. Fig. 26, bottom centre. Effect of bad driving conditions on the energy dissipated at the brakes: (a) The two curves are for good conditions obtained from Fig. 23a; (b) again, the curves are for good conditions obtained from Fig. 23b. Fig. 27, top right. The effect of bad driving conditions on the number of brake applications per mile. In this case, the curve for good conditions is obtained from Fig. 18. Fig. 28, bottom right. Effect of bad driving conditions on the mean rate of working at the brakes of the car. This curve is for good conditions obtained from Fig. 25

mined from equation (23), substituted in equation (31), the least area of braking path on the drum of ¼ in thickness is

$$A_1 = 0{\cdot}000208P \text{ ft}^2 \quad \ldots\ldots(33)$$

For example, if a car weighs 2,600 lb, then A_1 has to be 0·53 ft² to provide an adequate rubbing path area to prevent a drum temperature greater than 810 deg F from being developed in a 46 m.p.h. test.

The equation, corresponding to (33), for a 60 m.p.h. cyclic test when braking to the limiting temperature is

$$A_1 = 0{\cdot}00032P \text{ ft}^2 \quad \ldots\ldots(34)$$

and for a car of weight 2,600 lb, A would have to be 0·84 ft². This shows the importance of devising suitable fade tests that reasonably represent the most severe duty in normal driving and do not impose a ridiculous duty upon the brakes. Intensely severe tests can only be used in order to observe the break-down point of the brake system and, provided the test is interpreted from this aspect, it can be a useful yardstick for assessing development.

A similar formula to the foregoing has been proposed by Odier[15], who derives the expression for θ_s for a front cast iron drum as

$$\theta_s = \theta_o + \frac{yPu^{3/2}}{1000}\left\{\frac{4{\cdot}6u^{1/2}}{Kt_o} + 33{\cdot}3\frac{\sigma a^{1/2}}{A_1}\right\} \quad \ldots\ldots(35)$$

where P = weight of vehicle, kg
u = initial vehicle speed, km/hr
A_1 = rubbed surface, cm², of the brake path
a = deceleration in m/sec²
t_o = interval between applications, sec

The overall coefficient of heat exchange is K and can be expressed as $K = sA_1u^{1/2}$, where s represents a *coefficient of ventilation* which depends on the shape of the drum and on its mounting in a wheel. Values of K on actual vehicles may vary between 300-1,500 in the c.g.s. units used. Hence, finally for a front cast iron drum

$$\theta_s = \theta_o + \frac{1}{1000}\frac{yPu^{3/2}}{A_1}\left(\frac{4{\cdot}6}{st_o} + 33{\cdot}3\,\sigma\, a^{1/2}\right) \quad \ldots\ldots(36)$$

and for a front drum of any material

$$\theta_s = \theta_o + \frac{1}{1000}\frac{yPu^{3/2}}{A_1}\left(\frac{4{\cdot}6}{st_o} + \frac{9{\cdot}3\,a^{1/2}\,\sigma}{(K_1\rho_1C_1)^{1/2}}\right) \quad \ldots\ldots(37)$$

Of the quantity in the brackets, the first term represents the average temperature of the drum, and the second term that of the maximum increase in surface temperature throughout a single application. The latter is based on assumption of a thick brake drum, so the formula is more applicable to public service vehicles or for brake applications that are of very short duration. If the Odier formula (36) is applied to the 46 m.p.h. cyclic test, with a limit of θ_s of 450 deg C and $s = 0{\cdot}5 \times 10^{-3}$ c.g.s. units approximately, which Odier states is a typical value for a touring vehicle, then $A_1 = 0{\cdot}41$ ft². This is lower than the value given by equation (33) but the cooling coefficients are not comparable. Both formulae are important in brake design, but more values of the cooling coefficients are required.

These general formulae can be compared with the well known empirical expression HP/A for the determination of the rubbing path area A where HP is the maximum horse power developed at the braking surface. The term HP/A implies that the temperature rise

$$\theta_s = \frac{\sigma yPu_{max}^2}{4gJAC_1\rho_1d_1} \quad \ldots\ldots(38)$$

is attained at the interface of the lining and drum, where u_{max} is the maximum speed of the vehicle. If for the same limiting interface temperature rise, equation (38) is compared with equation (29) then

$$\frac{u^2}{A_1}\left\{\frac{1}{ht_o}+\frac{\alpha_1}{K_1 d_1}\right\}=\frac{u_{max}^2}{AC_1\rho_1 d_1} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(39)$$

and if $ht_o=0{\cdot}18$, $1/K_1 d_1=1{\cdot}04$ and $u_{max}=2{\cdot}6u$—which is true for the high power car considered above—when $u=46$ m.p.h, then $A_1=0{\cdot}94A$; but if $u_{max}=2u$, where $u=60$ m.p.h, then $A_1=1{\cdot}65A$ which explains the failure of the empirical formula at high braking speeds.

Alternatively, the empirical formula implies that $A_1=Pu_{max}/B$, where B is a constant, from which the braking surface is a function of the weight of the car and its maximum speed. This expression implies that, for two vehicles of equal weight, the rubbing path area required for one having a maximum speed of 120 m.p.h. would be 1·5 times that of another reaching 80 m.p.h. However, the Odier expression states that $A_1=Pu^{3/2}/B_1$, where B_1 is influenced by the materials used in the drums and linings, the ventilation of the drums and the conditions of use. When this expression is applied to the vehicles, the area of the high speed vehicle would be increased by $1{\cdot}5^{3/2}$ or 1·85 times that of the 80 m.p.h. vehicle. This again explains the failure of the empirical formula when extrapolated to high speeds.

The general formulae show why certain vehicles closely related in performance but with different brakes, that is, with P, u, a, t_o the same and σ, γ, A_1 and h different, have different braking characteristics. Though two vehicles may have the same P/A_1 ratio, the values of h for their respective brake drums may vary by as much as two-fold and, consequently, the first term may well change by a factor of two, and thus the brakes of one vehicle may perform well whilst those of the other develop troubles. Alternatively, if h is the same in the two vehicles, and P/A_1 different, then the interface temperature will be higher for the vehicle having a greater P/A_1 value, and the latter vehicle may consequently exhibit some braking difficulties. The remedy in this case is to ensure more efficient cooling, by exposing more drum surface to the air or using forced ventilation.

CONCLUSIONS

Part II

i. When long term cooling losses are considered, Newton's law of cooling may be applied to predict the variation of the rise in average temperature of either the drum or the lining during a series of regular braking applications.

ii. In long term braking, the limiting temperature eventually attained is independent of the thermal capacity of brake drums or lining and shoe. However, high thermal capacity causes a reduction in the rate of rise in average temperature and thus a bimetallic drum has an advantage over a plain cast iron one of the same weight during repeated braking under the same conditions.

iii. Disc brakes, by virtue of their greater cooling area as compared with drum brakes, more rapidly attain their limiting temperatures, which are slightly lower than the final drum brake temperatures in corresponding conditions.

iv. Analysis of brake usage measurements round a circuit shows that:
   (a) Work done $W=KV_m^n$, where V_m is the mean journey speed, K is a constant and n is also constant for a particular type of driving. The value n is dependent on the terrain, and is for example greater for an Alpine circuit than an English hill circuit.
   (b) The number of significant brake applications per mile is independent of the vehicle used and of the driver, but depends on the terrain and traffic.
   (c) The mean rate of working at the brakes is independent of the driver.

v. Expressions giving the temperature rise in single stops and in regular repeated applications can be combined to give a formula for determining the maximum temperature attained and, by specifying a value of the maximum permissible temperature, the area of braking path can be calculated.

vi. Random braking can be reduced to equivalent cyclic application: for example, analysis of the brake usage of a sports car in the Alps indicates that the energy dissipated in motoring down one of the Alpine passes is equivalent to 12 applications from 46 m.p.h. to rest, at a deceleration of 0·5 g at 30 sec intervals on a level track.

vii. The formula for the area of braking path has been compared with the conventional h.p/in^2 rating and it is shown that both results are in agreement at speeds of 46 m.p.h. but that the latter rating gives areas which are too small for higher speeds.

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Pipeline Identification

IDENTIFICATION of the pipelines of factory services is essential, both for the safety of maintenance personnel and to ensure rapid rectification of any trouble. To facilitate such identification, Gordon and Gotch (Sellotape) Ltd., have introduced Sellotape Pipeline Identification Tape. This can be applied in the form of one or more coloured bands at intervals along the pipe, to give a simple colour coding system. Colours to British Standard 1710 : 1951 are available if required.

As an alternative form of recognition, the tape can be printed with an abbreviated letter code, and/or the appropriate British Standard symbol. If still greater clarity is desired, for the benefit of inexperienced or colour blind staff, the name of the service can be printed in full. The tape is equally suitable for use inside or outside the factory; renewal, which is said to be rarely necessary at less than two-yearly intervals, can be effected much more speedily than can the repainting of bands. Further details of the Pipeline Identification Tape may be obtained from the manufacturer's offices, 8 to 10 Paul Street, London, E.C.2.

General view of one of the new dynamometer rooms at Luton. The main control console is visible to the left of the engine under test. Other features of interest are the excellent natural and artificial lighting, the thorough sound insulation and the full-width gantry on overhead rails

Vauxhall Dynamometer and Rig-Test Laboratories

New and Well-Equipped Installations at Luton for the Testing of Engines and Chassis Components

As part of their expansion and modernization scheme for the Engineering Department, Vauxhall Motors Ltd. are now operating the first section completed of a new dynamometer building at their Luton factory. The modern layout and equipment of this building are claimed to make it one of the most efficient of its type in the world. Also, an additional laboratory has been opened for the rig testing of components manufactured both by Vauxhall and by outside suppliers.

The new building, which will eventually have a floor area of 21,500 ft^2, has been designed to accommodate not only a total of 16 dynamometers, of various types, for testing petrol and diesel engines, but also a vehicle dynamometer, a cold room and test rooms for carburettors and fuel-injection equipment. A feature of its construction is the use of full-width windows in the dynamometer rooms, to give ample natural lighting. Venetian blinds are fitted to the windows, to minimize glare and to enable the rooms to be darkened for special tests such as those involving use of a stroboscope. Where fire protection doors are necessary, they are of the double type and are faced on both sides with plastics-coated steel sheet. The facilities of this building are supplementary to the dynamometer section in the main Engineering Department building, which accommodates nine machines.

In its present, incomplete stage, the new building houses three dynamometers, to which a fourth will shortly be added. The carburettor and injection equipment test rooms are completed, and are in full use, as are the offices, stores and rooms for equipment and services. In a room at the top of the building are installed the motor-generator sets and automatic control gear for the dynamometers, and the transformer equipment and distribution panels for the incoming electrical supply for the whole building. Equipment can be moved up or down through openings in the floor, between ground level and this room, by means of internal lifting tackle. To facilitate maintenance, and to keep the dynamometer rooms clear of unnecessary piping and wiring, all the services—electricity, water, compressor air, ventilating air and heating—are led through a plenum to the various rooms. As can be seen from the accompanying diagram, this forms an intermediate section above the ground floor and below the room housing the electrical gear.

Dynamometer rooms and equipment

Each dynamometer room measures 24 ft long × 16 ft wide × 11 ft high and is lined with sound absorbing material, behind which the various services are installed. The dynamometer and the engine bed plate are mounted together on a concrete block 4 ft deep and weighing 25 tons. This block is insulated from the surrounding floor and the foundations by a 2 in layer of cork. It has been found that such a combination of an inertia block and insulation effectively eliminates the transmission of engine vibration to the rest of the building.

The lighting is of the flush type, and the lifting tackle can span the full width of the room. Grills for the forced ventilation system are let into the ceiling and floor. The air is fed in from the ceiling, past adjustable guide vanes, and the input rate can be regulated as required, over a wide range, by means of an eddy-current coupling on the blower. Extraction of the air is effected through the floor grills, into under-floor ducts and thence to a stack. An interlocked control system makes it impossible for a dynamometer to be started without the ventilation system in operation. When the room is out of use, the system is kept going, at the minimum flow rate, to prevent any possible accumulation of inflammable vapour. From the rear of the bed, the engine exhaust pipe passes into the under-floor air extraction

duct and the gas is discharged from it at the top of the stack just mentioned.

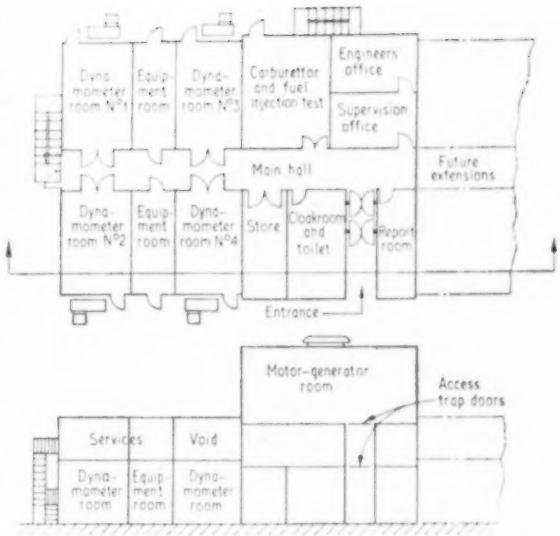
The three dynamometers already installed are products of the American General Electric Company; the fourth one, which will complete the first stage of the programme, was manufactured by Heenan and Froude, who were responsible for the layout of the rooms and all installation work. All four dynamometers are of the d.c. shunt-wound type and, whereas the G.E.C. units have a capacity of 150 h.p. and can run at up to 6,000 r.p.m, the Heenan and Froude machine is a 200 h.p. unit with a maximum speed of 5,000 r.p.m.

Special care has been taken to ensure accuracy, ease of control and reliability of the dynamometers: among the design features are oil-floated trunnion bearings for the carcases, remote torque indicating mechanism and provision for mounting accessories on the carcases. The G.E.C. units have pressure lubrication of the armature bearings, and on both types the cooling blowers are independently driven, so that the full torque capacity can be used at low speeds without risk of overheating.

An electronic system, of Ward-Leonard design, is employed on the G.E.C. machines to give automatic control of the speed and, for certain tests, the torque-speed relationship. Electronic control is not fitted to the Heenan and Froude machine, but provision is made for its embodiment at a later date if this is thought necessary. The layout of the instrument and control panels has been carefully worked out for the maximum convenience of the operator. Safety equipment is installed to shut down the plant if the dynamometer speed exceeds a pre-set maximum or if the oil supply to the trunnion bearings fails. Similarly, a shut down occurs automatically if the engine oil pressure falls too low or if the oil or coolant temperature becomes excessive. Additionally, there are push-buttons for stopping the equipment in the event of an external emergency.

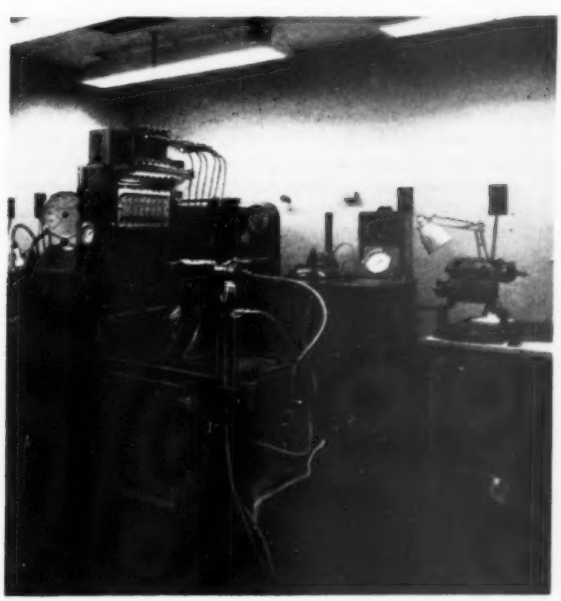
Between each pair of adjacent dynamometer rooms is an auxiliary equipment room. Among the equipment in the latter are heat exchangers for the engine lubricating oil and cooling water, also a vacuum pump, electrical switch and fuse gear, and the carbon dioxide cylinders for the fire extinguishing systems in the dynamometer rooms. The heat exchangers are of the dual-purpose type, in which one section is used to add heat to the system concerned, whereas the other is employed when heat abstraction is needed. Both the coolant and the lubricant systems form closed circuits with the engine, and embody a circulating pump and an automatic control valve. The connections to the engine are made from stand pipes flanking the bed.

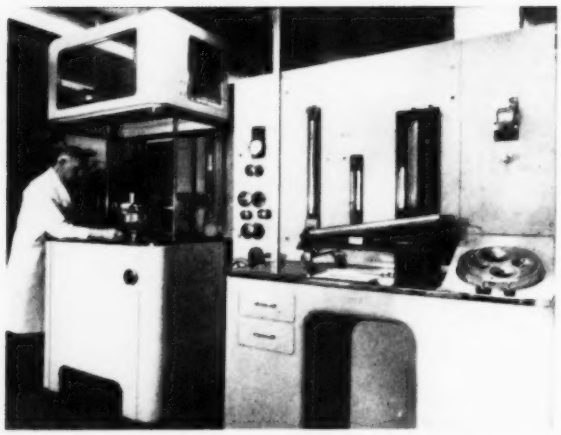
Heat is dissipated from the exchangers to an independent water system. This system is of the recirculatory type—in view of the large quantities involved—and embodies a large



Side elevation and plan diagrams illustrating the general layout of the new dynamometer building at Vauxhall Motors Ltd. It is noteworthy that provision has been made for considerable extensions in the future

Left: The test room for fuel injection pumps and nozzles. In the foreground is a Hartridge test bench for measuring pump delivery and the phasing of the elements; behind it is a nozzle spray testing machine. Right: Between each pair of dynamometer rooms is an auxiliary equipment room, which contains heat exchangers, a vacuum pump, electrical gear and carbon dioxide cylinders for the comprehensive fire extinguishing system





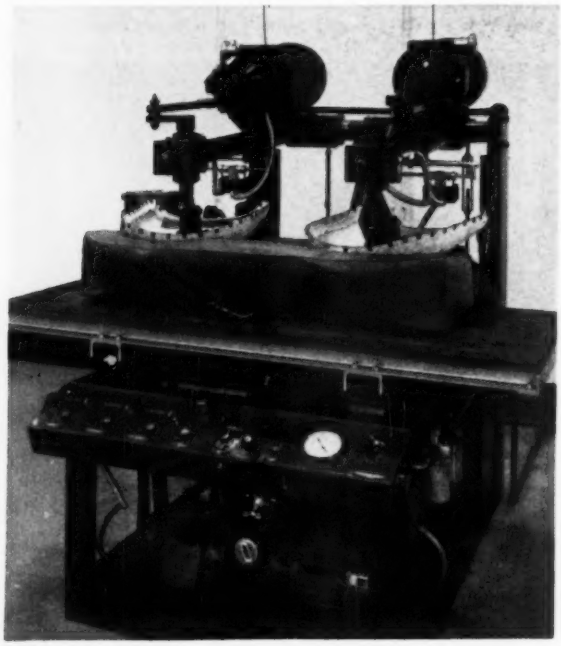
The carburettor test bench. On the left is the chamber, with its hood raised, and on the right are the flowmeter, manometer and orifices

Heenan and Froude cooling unit. To avoid scaling troubles, the water in the system is softened. The cooling and softening plant is housed externally, and the storage tank is below ground level and there is a pressure feed to the building.

Carburettor and injection equipment testing

Because of particular conditions involved, certain precautions have been taken in the construction and layout of the test rooms for carburettors and fuel injection equipment. A special flooring is employed, which is impervious to fuel oil and petrol, will not spark if struck and is slightly resilient to minimize damage if delicate components are dropped. The injection equipment room is a partitioned-off section of the carburettor room; this arrangement ensures the greatest possible freedom from dust in that section.

An ingenious rig has been evolved for testing seat cushions. The two dummies are given a violent up-and-down and oscillating movement



Flameproof electrical fittings are used throughout, and there is a continuous, forced ventilation system, in which the temperature of the incoming air is thermostatically controlled.

The flow test bench in the carburettor testing room is of Vauxhall design and manufacture. It comprises a sealed chamber, in which the carburettor under test is mounted, a vacuum pump and equipment and instrumentation for measuring air flow, fuel flow and depression. The chamber has a deep hood that is raised or lowered hydraulically, and an interesting feature is that sealing between it and the main casing is effected by a trough filled with mercury. Air is drawn through the carburettor by the vacuum pump, and the replacement air enters the sealed chamber through one of a number of calibrated orifices: the orifices are of various sizes to cater for carburettors of different mass flow characteristics. A normal fuel feed is employed to the carburettor, and the ingoing fuel passes through a flowmeter.

This flow test bench has, of course, the primary function of obtaining air:fuel ratios by direct readings of mass air and fuel flows. The readings are taken throughout the normal range of throttle openings and manifold depressions. Although the technique clearly cannot exactly reproduce actual operating conditions on an engine, it does provide a ready means of calibrating a new design of carburettor, or of assessing the effects of modifications to existing instruments. For each type of engine, an envelope of tolerance on air:fuel ratio against mass air flow has been established; when the graph of test results is compared with this envelope, it can easily be seen whether the carburettor departs from the requirements at any part of the throttle range.

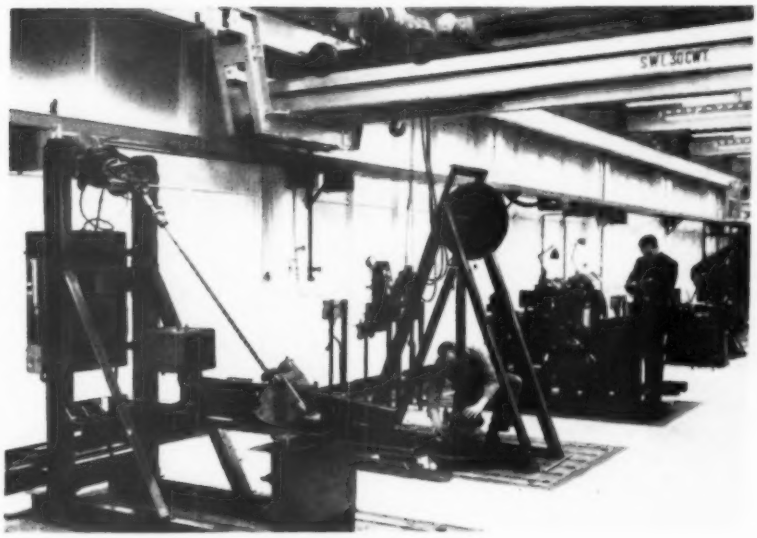
The main equipment in the test room for fuel injection pumps and nozzles is of Leslie Hartridge manufacture. There is the usual pump test bench for the accurate measurement of the delivery and phasing of the various elements of the pump. Also installed is a nozzle spray testing machine with which adjustments can be made to the delivery pressure, and a visual check can be made of the degree of atomization and the shape of the spray envelope. Other equipment includes a microscope, for viewing injector needles and seatings, and a grinding and lapping machine with which conditioning of these components can be carried out.

Fuel supply and distribution

To give the maximum flexibility with regard to programming the tests, petrol or diesel engines can be run on any of the dynamometers. In consequence, a rather complex fuel system is necessary. Two grades of petrol and one of diesel oil are held in underground bulk storage tanks a short distance from the dynamometer building. A separate building, near the tanks, houses the pumps, distribution panel and the supplies of special fuels, which are held in 40-gallon barrels. One set of pumps draws from the bulk storage, and another draws from the barrels, through flexible pipes.

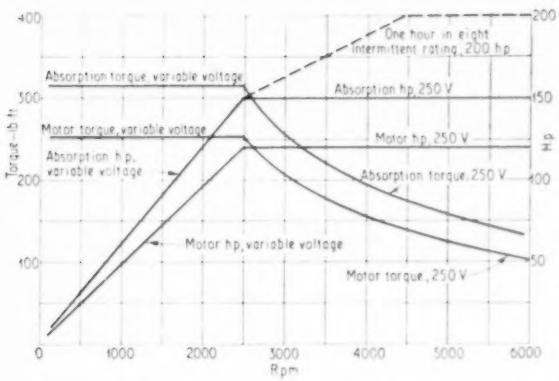
From the pumps, separate supply pipes lead to the distribution panel, where each pipeline has a series of self-sealing couplings. Below this panel is another, from which two delivery pipelines lead to each dynamometer room: one of these is for petrol and the other for diesel fuel, and each has a self-sealing coupling. Flexible hoses are used to make the appropriate connections between the supply and delivery couplings. This system eliminates the possibility of feeding more than one type of fuel into any pipeline.

From the distribution panel, the pipes are led underground, in a sand filled trench, to the dynamometer building, where each terminates in a float-controlled 2-gallon reservoir. These reservoirs are under the floor, outside the appropriate dynamometer room. An external pump circulates the fuel round a closed circuit connected to each



Right: Part of the new laboratory for the testing of components. The nearest rig is for the study of steering box life; next to it is an impact test machine, beyond which is a test rig for steering linkages. At the extreme right is a stroking machine

Below: Curves showing the power and torque characteristics of the G.E.C. dynamometers. Three of these 150 h.p. machines have been installed in the new building



reservoir; this circuit passes under the floor of the room, and fuel is drawn from it by the pump of the test engine. Prior to a change of test fuel, each reservoir and its associated piping is drained into one of two underground dump tanks, to avoid contamination. The selection of petrol or diesel fuel is made by a switch in the dynamometer room, and there is a second switch for use if a change of petrol grade is required. This switch operates the draining cycle, the completion of which is indicated by a signal light. Operation of the emergency stop button in the dynamometer room results in automatic dumping of the fuel as well as the immediate shutting down of the equipment.

Component testing laboratory

The new rig-testing laboratory for components supplements existing facilities. It serves the two-fold purpose of enabling the suitability of new designs to be assessed, and of ensuring that the required standard of existing components is being maintained. Because of the accelerated and controlled conditions of testing, much time is saved in comparison with testing on vehicles.

At present, there are about twenty installations in the laboratory. Among them is apparatus for testing gearbox synchromesh units, vehicle seats, road wheels, steering boxes, brake servo mechanisms and a wide range of electrical components. The durability of paint or underbody sealing compounds can be tested, and there is a versatile stroking machine, in which the stroke, speed and load are independently adjustable. Some of the equipment is well known and does not call for comment, but the methods employed in certain instances are of interest for the commendable ingenuity that they display.

In the seat testing rig, for example, there are two dummies representing the lower portion of the human trunk moulded in rigid plastics material; these are moved mechanically in a manner such as to produce a strenuous, combined up-and-down and oscillating action. This movement subjects the seat to a combination of impact and abrasion, so that both its strength and wear resistance can be investigated. Road wheel strength is tested by forcing together, under a known pressure, two wheel and tyre assemblies in the same plane; one of the wheels is motor driven, so the two rotate in opposite directions, and the tyres are continuously cooled by a water spray.

On the steering box rig, because the reversible electric motor providing the power is coupled to the upper end of the column, life tests can be carried out on column assemblies as well as the boxes themselves. The number of turns given to the column in each direction can be pre-set to provide lock-to-lock or intermediate actuation. A standard Girling powered steering jack unit provides the load against which the box must work. The stroking machine is often used for testing suspension springs and dampers, but it has the capacity for many other duties. Among these is the testing of the resistance of commercial vehicle fuel tanks to the type of impact stresses that could occur, for example, when a tractor unit is towing a semi-trailer. In this test, the tank is reciprocated continuously, with violent deceleration and acceleration at each end of the stroke.

Ergonomics

A CONFERENCE on ergonomics is being held, by the Department of Scientific and Industrial Research, from 27th to 29th September, 1960, in the Connaught Rooms, Gt. Queen Street, London, W.C.2. Among the many papers that will be delivered are the following: "Place of ergonomics in industry", by L. G. Norman, Chief Medical Officer, London Transport Executive; "Ergonomics at Renault", by A. Y. Wisner, Head of Physiological Section, Department of Scientific Research, Regie Nationale des Usines Renaults; "Human problems in transport", by G. C. Drew, Professor of Psychology, University College, London. Further particulars of the conference can be obtained from the D.S.I.R., Charles House, 5-11 Regent Street, London, S.W.1.

Electrostatic Painting

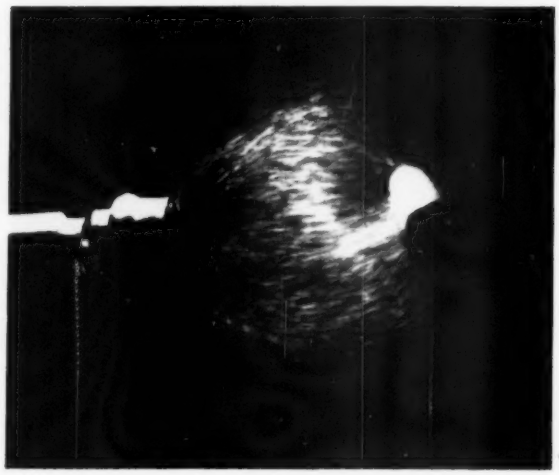
Aerostyle Ltd. Introduce the SAMES "Statron" Portable Apparatus and Spray Gun in Britain for Manual and Automatic Applications

FOR a number of years electrostatic painting methods have been used in a variety of industries in both America and Europe. In the main, applications were confined to mechanized installations arranged for continuous operation in large-scale manufacturing plants. The familiar picture was of components suspended from an overhead conveyor passing through an electrostatic booth in which one or more stationary or moving spray guns operated by compressed air were sited and appropriately directed.

With the Statron equipment developed by Société Anonyme de Machines Électrostatiques (SAMES) of Grenoble, France, the method employed is to atomize the paint mechanically by shearing it off the periphery of a rotating disc by centrifugal force. At the same time, the break-up of the paint particles is improved by an electrical field while they are being directed towards the object to be painted. This electrical field is produced by a new, patented high-voltage generator, the characteristics of which are designedly suited to the electrostatic painting process.

In the overwhelming majority of cases a continuous and uniform coating of paint, covering the whole object, can be obtained merely by spraying towards a single face of the object. Usually it is unnecessary to either turn the object or to move the gun around it. With merely average skill an operator can produce results of good quality and without overspray and waste of paint. Atomization, spraying, and coating can all be accomplished without using an air compressor.

Taking its power supply from any normal 110-130 V or 220 V A.C. line, and consuming only 100 W, the motor-driven generator, or "rotator" as it is termed, raises the voltage to 90,000. This unit may be simply described as a highly advanced, high-speed, modernized development of the early electrical experimenter's Wimshurst machine. In spite of the high voltage, the output is fundamentally safe since it has an extremely low amperage, actually 0·02 milli-

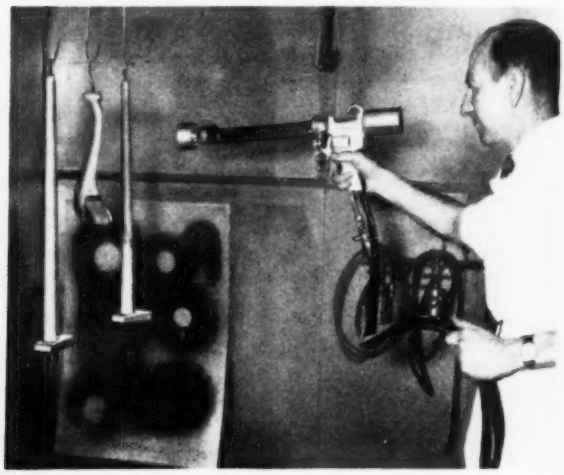


Detail of the paint spray issuing from the atomizing head of an electrostatic gun, showing "wrap" around a rod-like object

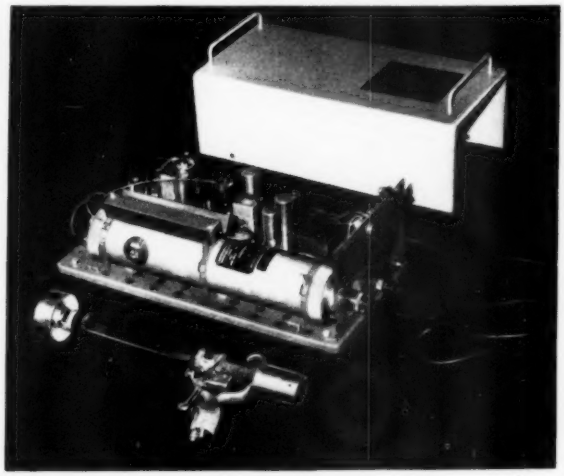
amps. It can be discharged to the human body without the slightest harm being incurred. Still higher voltages can be produced in order to secure increased "wrap" of the paint around the object or to obtain greater economy of paint by reducing random spray. These higher voltages remain definitely non-lethal. The generator is enclosed in a light metal casing that also houses a step-down transformer which provides a supply of current at 24 V for the spray gun motor.

A first visual impression of the gun, suggesting that it is long and consequently unwieldy, is immediately dispelled on handling. It is light and well-balanced and, as the illus-

The gun in operation. Work is suspended from a single, earthed wire. Characteristic spray patterns are shown in background



The generator unit is readily exposed for adjustment or maintenance by removal of the metal casing from the chassis



Statron generator and gun constitute a complete portable unit weighing only 60 lb. Consumption is 100 watts from a normal 110 V or 220 V supply

trations indicate, is designed for single-hand operation. The small 24 V motor which drives the centrifuging disc in the spray head at a speed of 3,000 rev/min is mounted to the rear of the main body and grip. Each gun is furnished with four interchangeable high-tension atomizing heads, with different diameter discs and coned nozzles. Selection of these heads is determined by the desired spray coverage and the quantitative supply of paint. Up to five gallons of paint per hour can be delivered using the largest head. Paint supply can be regulated to much lower values and a consumption of 60 cm^3/min—less than one gallon per hour —is an average for light coatings.

The high-voltage current imparts a negative charge to the paint particles, and the object to be painted is positively earthed. This is one of the factors determining the length of the spray gun. Since under normal conditions the operator is earthed and positive, he must not approach the paint spray too closely or paint particles may be diverted and he himself could be coated. It is usual to position the atomizing head of the gun about 6 in from the object to be painted, but this spacing is not critical and can be either increased or decreased within reasonable limits without ill effect. Working at this distance the operator is completely out of range. The necessary connections to the spray gun are high-tension and low-tension cables and, of course, a paint supply conduit.

A choice of methods for feeding paint to the gun can be made. Probably the simplest is a gravity system from a paint container mounted at a suitable height above the operating position. It can be fed through a small paint pump or the paint container can be put under pressure from the shop air line. A pressure of the order of 10 lb/in^2 is adequate.

The equipment can handle practically all commercial paints or varnishes, whether of the quick-drying, air-drying, or stoving class. Primers, undercoats, and special finishes can also be applied. Ordinary grades of solvents and thinners can be used in appropriate quantities should it be necessary or desirable to adjust the paint characteristics. It will be appreciated that the electrostatic method can be used to paint, in addition to all metals, materials such as wood, plaster and cement, and objects of any material that to some degree is conducive of electricity.

Economically, the electrostatic method of painting can show numerous and substantial advantages over more orthodox methods. By the virtual elimination of overspray, and also of over-coating to ensure complete coverage, the waste of paint is avoided. Reductions in the rate of paint consumption of from 40 to 70 per cent are recorded. Savings in labour time and production time are marked, since less gun manipulation is needed to obtain satisfactory coverage. The built-up component illustrated serves to show what can be achieved on such difficult work. Electrostatic painting cut the allowed time for this from 2½ min to 40 sec.

In combination, the savings in paint, time and labour can be remarkable. An example may be cited of batched work. By earlier methods a batch was completed by 3 operators in 8 hrs with the expenditure of 20 gal of paint. On the new method, 2 operators required only 6 hrs and 5 gal of paint. As the energy required for each gun is only 100 watts, some reduction of power consumed is to be expected. The equipment is easy and safe to handle and only a short period of training is necessary for previously unskilled labour.

In respect of operator health and shop atmosphere the usual problems are considerably lessened. Paint application does not cause fog, and ventilation is required only to remove solvent vapours. Much simpler systems are required and booths or enclosures are unnecessary. Operators do not need masks or special protective clothing.

Together, generator and gun form a self-contained unit needing only a source of electric power and a supply of paint. As such it lends itself to semi-automatic or fully-automatic operation. Installations can be built, or extended, to suit specific requirements without incurring heavy expenditure on plant or making inordinate demands on valuable shop space.

The SAMES Statron apparatus has found wide application in many industries throughout Europe. Aerostyle Ltd, of Sunbeam Road, North Acton, London, N.W.11, have acquired the sole distribution rights for this equipment in Britain and throughout the Commonwealth countries.

Built-up light alloy component for aircraft. Spraying time with Statron apparatus is 40 sec. With conventional equipment time was 2½ min

THE MACHINE TOOL EXHIBITION

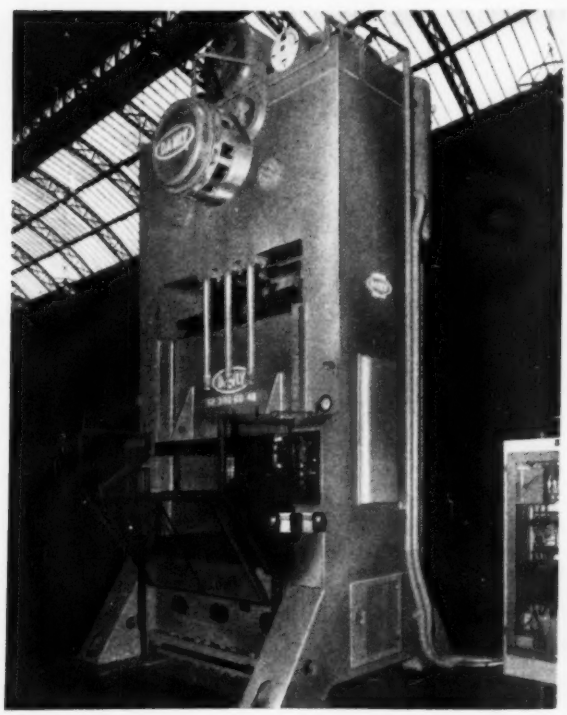
New Production Tools and Equipment in a Representative International Display by the Industry

WHEN the 1960 Machine Tool Exhibition at Olympia, London, closed on July 8th, it could fairly be adjudged an outstanding success. Reflecting the quickened rates of industrial production and the general economic expansion, previous records for size, range of exhibits, foreign participation, and the number of overseas visitors were all exceeded. The Exhibition was, of course, all-embracing in character and the tools shown were of types suitable for the finest instrument and miniature precision work extending to huge units for the production of the heaviest industrial equipment. Differing from any other exhibition of machine tools, in any part of the world, it was truly international in character. Of an approximate total of 1,350 machines on show 552, or about 41 per cent, were products of foreign manufacturers from eleven different countries. Foreign visitors, who constituted 10 per cent of the record attendance, were drawn from 79 countries.

Naturally, the automobile industry, following its exceptional rate of expansion and the pending large increases in production capacity, has exerted a marked influence on the machine tool trade. It could, in fact, be inferred that tools developed to meet, or to anticipate, the requirements of the automobile industry were so much in evidence that they constituted an outstanding feature of the exhibition in respect of numbers and varieties of types. What was probably the most significant item of business news during the period of the exhibition focused attention on this influence. This was the announcement of the finalizing of an order by the Ford Motor Co. for 27 large Danly presses for body panel work, to a value of approximately £1½ million. These presses are additional to those of a previous order from the Ford Motor Co. which are now approaching completion. As before, they will be to the designs of Danly Machine Specialities Inc. of Chicago, U.S.A., and will be built by Harland and Wolff Ltd., at their Scotstoun works.

In machines intended for the automobile and other highly competitive industries, designers are faced with divergent and often conflicting requirements. To obtain the specified rate of production, what is virtually a single-purpose, fully automatic, machine is indicated, yet it must be sufficiently flexible in design to permit relatively easy and rapid adaptation for another purpose should it become necessary. Again, where a basic product is to be manufactured in a range of differing models, a specialized machine must be capable of rapid changeover of tooling layouts in order to reduce to a minimum the down time in batched production. More machines are being built on the "block" principle so that time is saved in initial design and construction and delivery

Danly 300-ton, Series S, straight side, single action press



Lasco electro-hydraulic drop hammer with two-height control

times can be reduced. Standardized component units—drilling, milling, or grinding heads, for instance—can be re-utilized in the event of the machine becoming redundant.

Similar considerations influence press, machine, and transfer lines. To obtain the desired facility for possible rearrangement of sequence, and the addition or abstraction of a machine, lines are laid out with shorter transfer sections, multi-station rotary transfer machines, and individual units connected together by portable conveyors and transfer equipment. Such arrangements lend themselves to the provision of lateral storage banks at suitable positions in the line so that when an individual machine or group of machines is halted for a tool breakage or service replacement it is not necessary to stop the production flow. Much has been learned in this respect in recent years and much ingenuity has been applied to circumvent rigidity of layout and sequence, and also, in view of rising production times for single-action presses. The illustration shows a typical Danly straight-side press at Olympia. This example has a rated capacity of 300 tons. The sole agents for Danly presses are Gaston E. Marbaix Ltd, London, S.W.11.

It is of some interest to note that all these presses are of the overdrive type. In recent years there has been a marked swing towards the use of underdrive presses in large shops in the automobile industry. A remarkably good case could be made for the choice of this type since it reduced top hamper, permitted lower roof height and freer crane movement, enabled maintenance work on the drive unit to be carried out at low level and below the shop floor, thus minimizing any interference or obstruction in the main shop and not withdrawing the shop crane from its routine duties. Some remarkable installations of underdrive presses in this country have aroused widespread interest. It would seem, however, that the improved facilities for maintenance and

Danly "Quick Die-Change" underdrive press in a European automobile press shop

demands, to minimize the space occupied. This last consideration is currently assuming more importance.

Presses

The Danly presses ordered by the Ford Motor Co. are all of the straight-side type having relatively long strokes and large shutheights. Fronts and backs of these presses are open for feeding and drag-out. Four presses are double-action, Series D models with a rated capacity of 700 tons. This figure relates to the inner slide only; the blankholder pressure is additional. The remaining 23 presses are single-action, Series S models. Of these, 19 are of 800 ton capacity and four are rated at 400 tons each.

On the double-action presses, the two-speed Danly clutch is fitted. This unit consists of two concentrically mounted, air-operated, friction clutches. The high-speed clutch, mounted in the flywheel, gives a relatively high stroking speed for return and approach; the low-speed clutch operating through reduction gears gives a lower stroking speed for the draw portion of the stroke. In this case, the speeds are at the rates of 12 strokes/min and 6 strokes/min respectively. Use of the two-speed clutch reduces the overall cycle time, bringing it in to closer conformity with cycle dealing with temporary shutdowns have been somewhat over-estimated in view of the current standard of reliability. As a consequence they are, in some quarters, now deemed of insufficient importance to justify the 15 to 25 per cent higher initial cost of the underdrive press and its installation. The choice as yet cannot be regarded as finally determined, but the signs are that the overdrive press will be used in all but exceptional cases.

Although examples were not on show at the Exhibition, a modified type of Danly press—in straight-side, overdrive or underdrive, single-action and double-action designs—merits attention and may be quoted as illustrating the point made earlier regarding special provisions for rapid tooling changeover. Known as "Quick Die-Change" presses, they render the relatively short runs, made necessary by controlled production planning, economically feasible. The press uprights are apertured to permit a die carrier and die to pass into or out of the working area. Each press is provided with two bolster plates mounted on wheeled, power-driven, heavy-duty carriers. Bolster and carrier together make a die-carrier assembly.

Die carriers move on tracks at floor level, arranged at right angles to the production flow, and consequently a

changeover can be effected without removing handling or transfer equipment between presses. Loading and unloading positions are under craneways between lines of presses and when the carriers are not being worked they are parked partially in the uprights to clear the aisles. The carriers can be loaded or unloaded when the crane is available.

Under push-button control the carrier is moved into the working position against positive stops. The carrier wheels are then resting on lifter plungers in hydraulic cylinders in the press bed. These plungers are retracted to allow the carrier to be accurately located over keys and to rest solidly on the bed. It is then secured by holding-down bolts. When a carrier is withdrawn from the press an interlock circuit is broken and the press becomes inoperable. This circuit is completed when the other carrier is brought in and correctly located and seated.

When in the loading position, an adaptor plate is bolted to the upper half of the die. After the carrier is bolted down the slide is adjusted down until it almost contacts the plate, which is then clamped to the slide by manual, semi-automatic, or fully automatic means.

Drop hammers

The range of Lasco self-contained, electro-hydraulic, drop forging hammers currently produced by the German firm of Langenstein and Schemann AG, of Coburg, comprises eleven hammers with blow ratings of from 4,540 ft-lb 45,400 ft-lb. Designated Type KH, all incorporate the firm's patented two-height stroke control system. Illustrated is the KH 12-5 hammer shown at Olympia; the appended number indicates a rating of 1,250 mkg, or approximately 9,000 ft-lb. Using standard dies the drop height is 39·4 in and the tup weight is 25 cwt. Distance between the uprights is 18·9 in and the tup depth is the same. Total weight is 28 tons and the overall height above floor level is 16 ft 3 in.

Housed in the crown, which is flexibly mounted on the uprights, the complete electro-hydraulic unit is powered by a 22 kW, three-phase, electric motor directly coupled to the high-pressure pump. It is equipped with a cooling system to maintain the operating oil at its optimum temperature. There are no piped connections, all communications being established by integral cast ducts. The circuit and control system are so designed that the tup motion is reversed immediately after impact, irrespective of the position of the tup in relation to the total available stroke. Top pressure to obtain increased tup velocity is variable between certain limits. Chill-cast tup guides, detachably mounted in recessed seatings in the uprights, are each in two parts. Removal of the lower half-guides enables the tup to be withdrawn without the need to dismantle the crown.

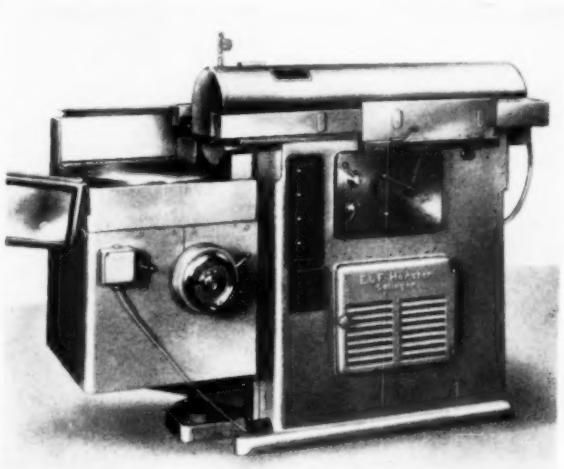
Accuracy in forging is largely dependent upon the rigidity of the hammer frame and the close alignment of the tup guides. On Lasco hammers the uprights have large bearing and guide surfaces contacting with the anvil block and are displaceable transversely by means of two screw-adjusted wedges. The long bolts securing the uprights to the anvil block are fitted with packs of spring discs to impart a certain resilience. At their heads the uprights are connected together by heavy-section tubular distance pieces.

With the two-height control system, the heights of fall for a heavy blow and a light blow are set on two dial selector switches on the control column. These switches, which can be locked by a key to prevent interference, are controlled by side-by-side switches on a mobile pedal control unit on an armoured flexible cable. Left and right switches are for light and heavy blows respectively, and can be operated from either a standing or sitting position, for single or repeated blows in any desired sequence. The control system operates on 24-volt D.C. and has no mechanical linkages. An electrical failure ensures that the tup is locked. It is claimed that die wear is reduced since unnecessarily heavy blows are avoided and only the energy required can be applied.

Agents for Lasco hammers are Paul Granby and Co. Ltd, 39 Victoria Street, London, S.W.1.

Surface grinder

Five models of the SBFR rotary-table, surface-grinding machine, manufactured by E. and F. Hörster, of Solingen, Germany, have magnetic work tables ranging from approximately 16 in to 40 in diameter respectively. Illustrated is No. 600, equipped with a 24 in diameter table. Directly driven by a pole-change motor at 1,430 or 2,850 rev/min, the wheel spindle is mounted in a horizontal sliding ram and hydraulically traversed across the table. The ram is massively proportioned, its size being such that any vibration excited during grinding is absorbed by its own weight.



Hörster SBFR rotary table, surface grinding machine

Ram speed is steplessly variable from 6 to 118 in/min, and stroke length and reciprocation are set by means of reversal dogs.

The magnetic table is mounted in a gear unit that bodily is raised or lowered in vertical slideways. It can be tilted 2 deg in a vertical plane containing the wheel spindle axis to enable concave or convex grinding to be carried out when required. Vertical feed of the table towards the grinding wheel can be automatic, with rapid approach, or manual by means of a handwheel. The handwheel has a ring graduated to 0·001 mm (0·00004 in) and is also fitted with a dividing lever, a single depression of which adjusts one graduation.

A special feature of the machine is the use of an Enor fluid drive system for rotation of the work table. With this, table speed can be steplessly varied from zero to 140 rev/min. A selected rotational speed is set on the control unit and thereafter the corresponding circumferential speed of the table immediately below the grinding wheel is maintained at a constant linear value under the influence of ram movement; that is, the rotational speed of the table is continuously increased as the grinding wheel moves from the periphery to the centre and *vice versa*. Thus the surface finish of different workpieces, or of different areas of a single workpiece, is of a uniform quality.

The varying speed control can be cut out if desired, when grinding large diameter rings of small width, for example,

and the table run at the most suitable constant speed. Splash guards enshrouding the working area can be swung back on hinges to give access for loading and unloading, and for cleaning the table. Selling agents for these machines are Soag Machine Tools Ltd, Lambeth, London.

Gear finishing

In spite of reasonable precautions and normal care, a high rate of production brings certain hazards to such precision-machined components as transmission gears and pinions. Reference is made to the nicks and burrs resulting from handling or transfer from machine to machine. These, in conjunction with the occasional slight aberrations arising from hardening or heat treatment, may necessitate careful inspection and time-consuming correction. In order to obtain gears that will operate at an acceptable noise level it is not uncommon for gears to be matched and lapped in pairs. The Model 999 Hard Gear Finisher, manufactured by the Michigan Tool Co, of Detroit, U.S.A, is designed to finish a variety of hardened spur and helical gears of small and medium size on a production basis.

On this machine a toothed, gear-like abrasive wheel is rotated in tight mesh with the hardened work gear which is traversed across the abrasive wheel for its full face width. As the traverse is reversed at the end of each stroke, so the direction of rotation is automatically reversed. The tool head is mounted on precision roller bearings to reduce frictional loads and the head is maintained at a preset, counterweighted pressure bringing the tool into engagement with the work. This pressure can be adjusted to the requirements of specific applications. The abrasive tool, as a consequence, is protected from shock loads arising from severe runout or the occasional heavy nick in a gear. On the completion of a finishing cycle of a specific number of reciprocations, the tool head moves back automatically to give access for unloading and re-loading.

The kinematics of the work table traversing movement tends to retain or enhance any slight crowning of the teeth originally generated in the gear. For gears requiring a more pronounced crown on the teeth, a standardized crowning attachment can be fitted. With this, an adjustable sine bar arrangement controls pivotal motion of the work table as it reciprocates the gear across the abrasive tool.

Abrasive finishing tools are of the throwaway type, discarded at the end of their useful life. Since they are engaged to full depth under pressure they are virtually self-dressing as regards form. It is thus merely necessary at appropriate intervals to true the outside diameter. Maximum diameter of the abrasive wheel is 9¼ in and work from 1½ in diameter to 12 in diameter with a maximum face width of 5 in and a maximum length between centres of 30 in can be accommodated. Cycle time, depending on the size and character of the work, is from 20 sec to 3 min.

The machine may be used, after all gears have been sound tested, to finish only those having an unacceptable noise level. These components, on retesting for noise, are either passed or returned for further finishing treatment. On a production basis, it may be convenient to finish all gears before sound testing. If desired, the finisher can be supplied with a base on which a sound testing unit can be mounted. Equipment for automatic loading can be applied, the operator needing only to fill the loading chute. For full automation, work may be fed in from an overhead supply line and a continuous conveyor could transfer the parts to the next operating station.

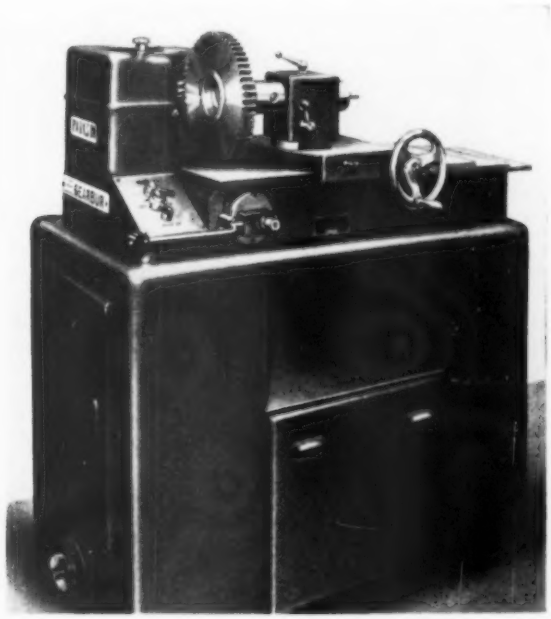
Gear deburring

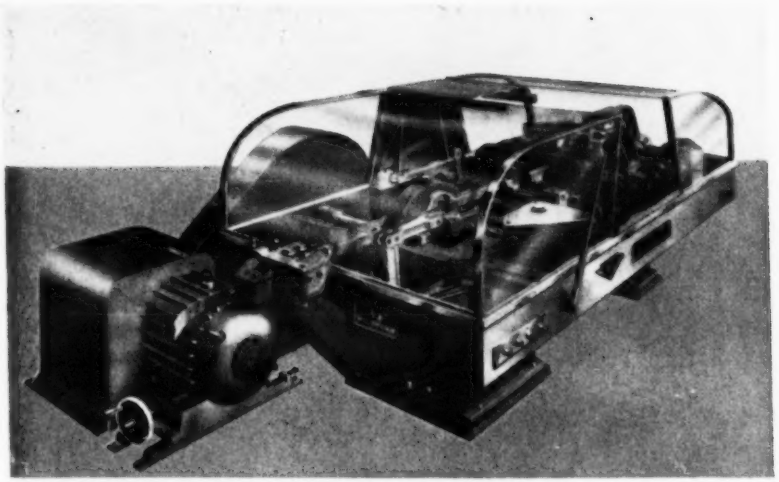
Many methods and machines have been used to remove the troublesome burrs and sharp edges from gear teeth. The Gearbur machine, introduced by J. Parkinson and Son Ltd, Shipley, Yorkshire, makes a new approach to the solution of the problem. In operation it is speedy, since it treats all the teeth of a gear collectively instead of individually, and as the tool is an abrasive wheel it can handle hardened or unhardened work with equal facility.

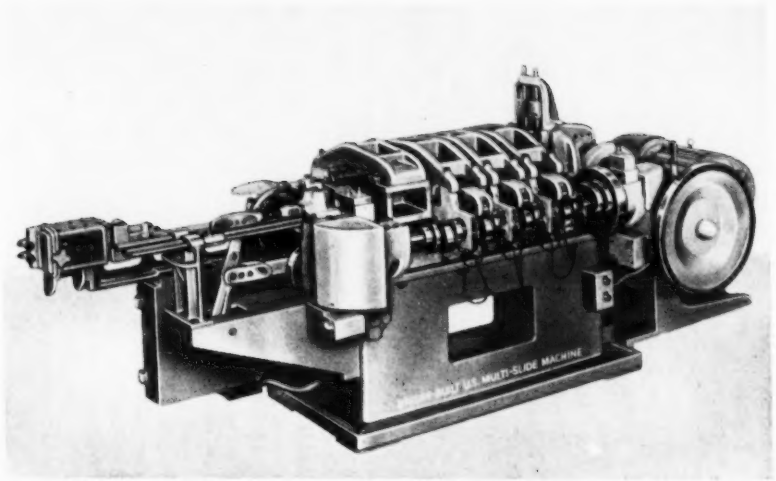
The gear is mounted on a freely rotating horizontal spindle, offset from the axis of a vertical spindle carrying the abrasive wheel at the same axial height. This wheel is formed on its periphery with a profiled helix to suit the pitch and tooth form of the gear. The work table is

Michigan Model 999 abrasive wheel, hardened gear finisher

Parkinson Gearbur rapid deburring and chamfering machine

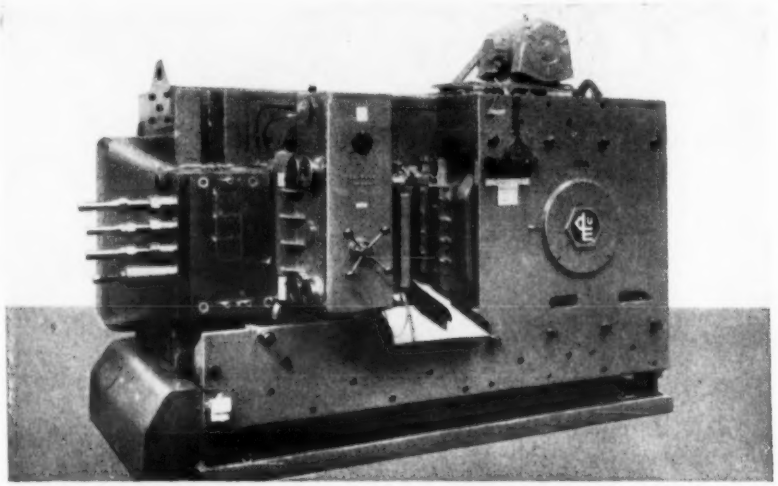


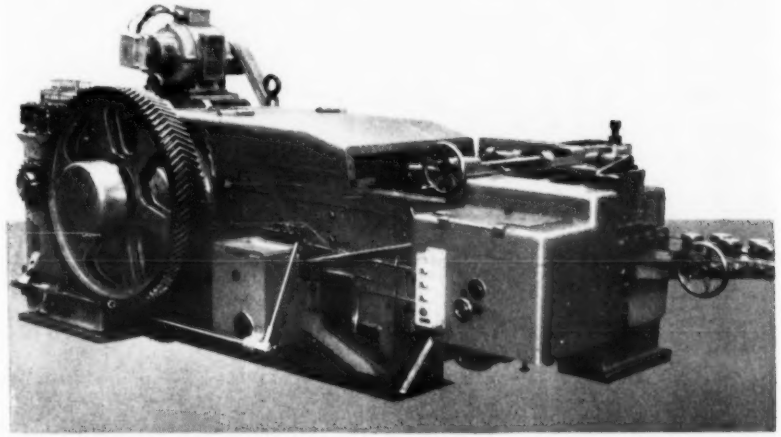




High-speed, coiled strip forming machines. Left: Heenan and Froude Model S.3 Multiform. Right: U.S. No. 35 Multi-Slide. Each machine can handle stock up to 3 in wide and $\frac{3}{32}$ in thick

Transfer type, cold heading, forming, and extruding machines. Left: Peltzer and Ehlers GB100, vertical transfer, max. cut-off $\frac{3}{8}$ in. Right: Greenwood and Batley 4-station, horizontal transfer, max. cut-off $\frac{5}{16}$ in





traversed longitudinally so that the gear teeth approach the abrasive wheel to contact at an angle of approximately 45 deg in plan.

When the gear teeth are brought into mesh with the threads of the grinding wheel, operation of a lever switches on the 1 h.p. motor which drives the grinding wheel at a speed of 2,830 rev/min and, in turn, rotates the gear. Further movement of the lever sensitively feeds the gear wheel into deeper engagement until all the tooth flanks and the bases of the tooth spaces are deburred and slightly chamfered. Return of the lever withdraws the gear out of engagement and switches off the driving motor. The work table is then traversed back by the handwheel and the gear is either unloaded or reversed on the spindle for a second operation to chamfer the teeth on the opposite side of the gear. Only a few seconds are required for a complete operation on one side of a wheel.

The grinding wheel is 8 in diameter and 1¼ in wide and the machine can handle gears up to 11 in diameter with teeth of from 25 to 5 diametral pitch. A single profiled grinding wheel will deburr and chamfer gears of different numbers of teeth providing they are of the same pitch and pressure angle. Wheels can be profiled and dressed in a suitable screw-cutting lathe using a carbide-tipped form tool. Templates for use when grinding these tools for various pitches and pressure angles are available.

Providing a suitably profiled abrasive wheel is already in hand, the setting-up time for a new batch of work will not exceed five minutes. Floor-to-floor time for each side of a gear need not exceed 10 seconds. Right-hand and left-hand helical gears can also be processed with a wheel profiled to suit the transverse pitch and tooth form. A fan driven from the wheel motor at approximately 9,000 rev/min draws off dust and swarf produced in the deburring operation. The dust is collected in a water settling tank and the cleaned air is returned to the shop.

Strip forming machines

Multiple-slide machines for automatically forming small, and often complicated, components from coiled strip and wire stock are capable of very high production rates. Their scope has now been extended to considerably larger components by the building of more powerful machines that can handle heavier stock material. An example of such machines is the Model S.3, the latest and largest addition to the Multiform range of forming machines built by Heenan and Froude Ltd, of Worcester. This can produce complex components from strip, up to 3 in wide and $\frac{3}{32}$ in thick, up to a blank length of 12 in, at speeds of from 40 to 120 pieces/min.

Accurate feeding of the strip is an essential. On the reciprocating feed mechanism the stock is gripped by cam-operated flat dies incorporating a self-contained locking device, thus avoiding sustained thrust on the feed slide. Further flat dies hold the strip securely on the return stroke of the feed slide. Adequate room is provided on the bed-plate for two press units in addition to the standard front cut-off. The 30-ton horizontal press unit has a 10 in die space and can be adjustably mounted along the bed to obtain optimum working position. Each of the four slides is individually operated by a hardened and ground cam capable of exerting a force of 6 tons on the component. Cams are of the pick-off type, split for easy removal, bolted to keyed-on back plates.

All four camshafts are interconnected by gearing and a flywheel is incorporated in the drive to ensure smooth operation. This flywheel can be uncoupled manually or automatically so that the stored energy does not have to be dissipated in the working mechanism before the machine is brought to rest. Controls can be linked electrically to ensure an automatic stop under such eventualities as short feeding, buckling of strip, or running out of stock. Differing from earlier Multiform models, the flywheel is located at the left-rear of the machine, improving the operator's access to the tooling layout.

Of another range of coiled-strip forming machines, the U.S. Multi-Slide series, two models are now built in Britain by Alltools Ltd, of Brentford, London, and marketed by Rockwell Machine Tool Co. Ltd, of London, N.W.2. The larger of these, No. 35, has a stock capacity of 3 in width by $\frac{3}{32}$ in thickness and the maximum length of feed is 13 in. It is powered by a 7½ h.p. motor, driving through a variable speed unit and vee belts to a flywheel and thence by a friction clutch to the main shaft. The clutch can be disengaged by a stop button or automatically through a system of safety switches. An electrically operated brake is applied simultaneously with clutch release. Operating speeds range from 40 to 160 strokes/min.

On this machine, in addition to the four forming slides mounted in hardened and ground steel ways, up to four die heads can be used. Each head carries a die set in which are mounted tools for such operations as piercing, trimming, extruding, shearing, preforming, or cutting off. If required, a 100-ton toggle press can be used simultaneously with two die heads, giving a total available force of 180 tons. A flat-strip stock straightener, supplied as standard equipment, is of the hinged type with individually adjustable rolls.

Die heads, forming slides, cut off, and stripper mechanism are all actuated by cams mounted on four mitre-gear connected shafts extending around the machine bed. A wide variety of auxiliary equipment is available, some items being intended for the performance of an additional operation in order to avoid the necessity of secondary handling.

Cold forming

Numerous small to medium-sized parts that formerly were machined from bar stock on capstans or automatics are now cold-formed at lower cost by what has been termed "chipless" production. The method is not without limitations, mainly in respect of the properties of the material, the method to be employed, and stress and consequent serviceable life of the tooling. If the heading ratio (free heading length to stock diameter) exceeds 1·8 the operation must be divided into two or three stages to avoid buckling. Extrusion is particularly suitable as the forces are compressive and are exerted in two axes. Relatively difficult parts may be formed by a combination of heading and extruding operations. Gear tooth profiles can be produced by a trimming process and eccentric details by a coining operation.

Specifically designed for cold forming operations, using both heading and extrusion processes, is a series of four "Boltmaster" fully automatic, four-stage, transfer-type forging presses manufactured by Maschinenfabrik Peltzer and Ehlers, of Krefeld, West Germany. (Selling agents are Rockwell Machine Tool Co. Ltd, London, N.W.2.) The largest of these, weighing approximately 60 tons, can produce components up to 10 in long by heading or 6¼ in long by extrusion. Maximum stock diameter is 32 mm. Illustrated is a smaller model, GB 100, handling wire up to 16 mm diameter and producing parts up to 5 in and 2¾ in long by heading and extrusion respectively. Operating speed is from 70 to 90 stroke/min.

Stock is fed by power-driven rolls through a two-way straightener to the cut-off station. The blade places the cut-off blank in a swivelling fixture that turns it through 90 deg into the pressing direction and then inserts it in the holding device of the first transfer arm. This arm holds the blank in front of the first die station until it is thrust into the die by the advance of the punch on the main slide.

On the completion of the stroke, a cam-actuated ejector pin slides the blank out of the die and into the holding device of the second transfer arm. This sequence is repeated up to the last die station, where any necessary trimming is effected. By the method employed, the trimmings are positively held until both scrap material and finished parts are discharged by way of separate chutes.

The main slide arms run in long guideways permitting accurate alignment of the tools, which are mounted in a single, adjustable block. Tools and dies are accessible and can be rapidly changed. All operations are visible to the operator. Safety limit switches stop the machine through a friction clutch should a part fail to be ejected and prevent a transfer arm reaching its end position.

A transfer-type cold forging machine built by Greenwood and Batley Ltd, of Leeds, has four die stations arranged in horizontal instead of vertical sequence. Weighing approximately 19 tons, its nominal capacity is $\frac{7}{8}$ in diameter × 3 in under the head, but the cut-off capacity is $1\frac{9}{16}$ in diameter in order to permit double or triple extrusion if necessary. Maximum and minimum cut-off lengths are normally $4\frac{1}{2}$ in and $\frac{1}{4}$ in respectively. Output is at the rate of 100 blanks/min. The machine is frequently used for the production of engine valves and can operate on the appropriate alloy steel wire stock.

Drive is by a 20 h.p. 1,400 rev/min motor of the slip ring type, mounted on the top of the machine, through vee belts to a flywheel and clutch unit on a transverse drive shaft. The other end of this shaft carries a double-helical pinion engaging a gear wheel on the main crankshaft. Wire stock is drawn through straightening rolls by feed rolls that are driven through a roller friction clutch. Cut off and carry over to the first die station is by an open blade, with a cam-operated transfer finger to retain the blank. The blanks are carried from station to station by fingers operated by a rack and pinion mechanism. Fingers are individually adjustable and can be swung up from the die cavities for tool setting.

All four punches are of the same dimensions, $2\frac{1}{8}$ in diameter × $5\frac{1}{2}$ in long. Dies would normally be of the built-up type in sleeves having external dimensions of $3\frac{1}{8}$ in diameter × 5 in long. Both punches and dies are fitted with cam-operated ejectors. If a trimming operation is required it is performed at the fourth station. In that case a trimming die is used and the trimmed component is discharged through the slide.

Micro-switches are fitted to the transfer devices, the punch ejectors, and the die ejectors. In the event of a tooling failure the machine is stopped almost instantaneously by the motor plug brake in conjunction with a powerful band brake on the drive shaft.

Turret milling machine

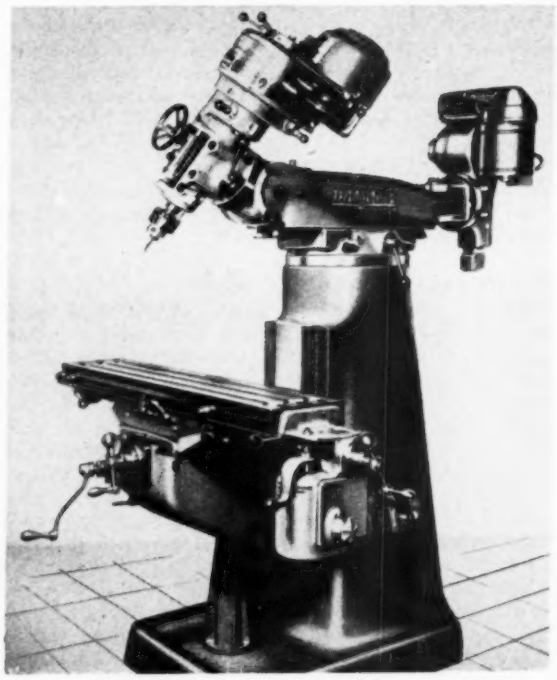
A machine that enjoys a considerable reputation in the U.S.A. by reason of its versatility, the turret miller manufactured by Bridgeport Machines Inc, of Connecticut, is now built under licence in Britain by Adcock and Shipley Ltd, Leicester. Between the years 1951 to 1958 production in America was raised from 28 to 125 per week.

The machine has a one-piece column and base, with a vertical slide at the front to carry a normal knee, cross slide and table. On the top of the column there is machined a circular face and bore on to which a turret is mounted. This turret carries in a suitable slide a ram with provision for mounting power-operated heads on both ends. One end of the ram has a swivel mounting which by worm and wheel provides an angular adjustment in a vertical plane about an axis normally parallel with the table movement. The head itself is provided with an adjustment in a vertical plane by worm and wheel about an axis normally at 90 deg to the direction of the table movement. This end usually carries a 1 h.p. heavy-duty milling head with eight speeds from 62 to 2,265 rev/min, three reversible power feeds, 5 in quill travel, and lever feed by hand as well as a wheel for slow hand feed. The other end of the ram is provided with a mounting permitting swivelling in a horizontal plane, and a variety of attachments can be mounted there, being brought into use by rotating the turret through 180 deg.

Movements available in addition to the normal table, cross slide and knee are, therefore:

1. Angular movement of the turret in a horizontal plane.
2. Longitudinal movement of the ram by rack and pinion in the turret. In conjunction with "1", this enables the spindles of the heads to reach all over the table, covering an area approximately 70 in × 20 in.
3. Swivelling of head by worm gear in a vertical plane about an axis at 90 deg to ram movement, permitting milling, drilling and boring at angles to the table movement.
4. Swivelling of head by worm gear in a vertical plane about an axis at 90 deg to the axis of the other swivelling movement, allowing machining at angles to the cross slide movement and, in conjunction with "3", machining at compound angles.

The range of alternative and supplementary attachments



Bridgeport turret milling machine, by Adcock and Shipley

is most extensive. A lighter, $\frac{1}{2}$ h.p. milling head has six speeds up to 4,000 rev/min and $3\frac{1}{2}$ in travel. Two heads, with $\frac{1}{2}$ h.p. and $\frac{1}{4}$ h.p. drive respectively, have fixed spindles, and each can be fitted with right-angle attachments for such jobs as milling pockets in cavities. Profile milling, hydraulic copying, slotting, cherrying and co-ordinate drilling can be arranged, and the latest innovation is a T-ram, on which up to four heads or three heads and a tracing attachment can be mounted. This allows up to four components to be machined simultaneously.

Being primarily intended for small-quantity work, the machines are commonly arranged for hand feed only. A

power-feed unit for the table is available, however, either as initial equipment or for the ready conversion of existing hand-feed machines. Standard table size is 42 in × 9 in giving 30 in traverse, but optional table lengths are available. Cross traverse is 12 in and movement of the knee 16 in.

British-built machines are for sale throughout the world, except for the Americas and Japan. In the United Kingdom machines will be sold by Adcock and Shipley Ltd, and also by Catmur Machine Tool Corp. Ltd, Lancaster Road, London, W.11.

Double-side grinding machines

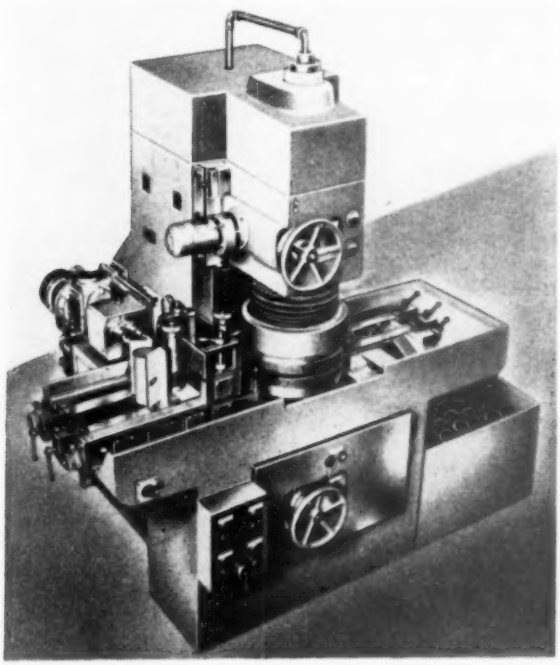
A specialized high-production machine for grinding both sides of relatively shallow workpieces is manufactured in four sizes by Diskus Werke AG, Frankfurt am Main—Fechenheim, Germany. The model illustrated is Type DDS 600, which has 24 in diameter grinding wheels and will admit work up to 8 in wide and $2\frac{3}{4}$ in deep. These machines, there are two smaller and one larger models, are arranged with opposed, contra-rotating vertical spindles, and the work is fed between the wheels continuously from left to right. Although work can be loaded manually, it is usual to fit a vertically stacking magazine from which individual parts are picked off successively by a conveyor belt and delivered between a pair of spring-loaded feed rollers. These push the workpieces between the grinding wheels at a predetermined rate of feed which is infinitely variable between 4 and 40 ft/min. On emerging from between the wheels, the finished component is delivered by way of an inclined chute to a collection bin. Throughout the traverse across the machine, the work is guided between tensioned steel tapes. The pitch of these tapes is readily adjustable to suit the width or diameter of the work being processed.

Wheelhead spindles run in adjustable roller bearings, and large diameter quills are used instead of slideways for vertical adjustment. In-feed increments can be as low as 0·0001 in. The upper spindle head is adjustable in normal vertical planes to permit setting for parallelism of the two grinding wheels. Spindle motors are housed in the machine column and drive the spindles through multiple vee-belts.

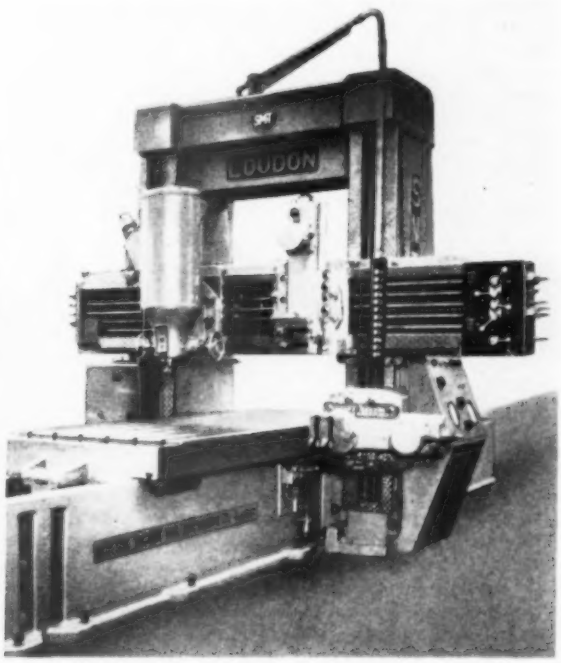
Grinding wheels are of the solid type with moulded-in nuts to permit their direct bolting to the steel carrier discs and can be used down to a relatively shallow depth with a minimum amount of waste. Coolant is fed through a small central bore in each wheel.

Work can consistently be held to close limits of accuracy while maintaining high rates of production. One operator can, of course, tend several machines. Typical components handled on these machines are bearing rings for ball or roller races, circlips, packing discs, thrust washers, piston rings, clutch discs and friction material-faced clutch discs. Typical production rates for a piston ring $2\frac{1}{4}$ in diameter, finish ground by the removal of 0·004 in stock, are approximately 5,000 pieces/hour. Another piston ring, $3\frac{7}{16}$ in diameter, is ground in two passes. The first pass removes 0·016 in and the second, finishing, pass removes 0·004 in. The rate for the complete operation is approximately 1,800 pieces/hour. With both of these examples accuracy is maintained closer than 0·0002 in for flatness and parallelism.

An alternative version of the Diskus machine is fitted with a rotating work table. This also is provided with a magazine feed, the workpieces being delivered directly into suitable apertures in a guide disc and automatically ejected after passing between the grinding wheels. Agents for Diskus Werke machines are Rockwell Machine Tool Co. Ltd, Edgware Road, London, N.W.2.



Diskus DDS 600 automatic, double side grinder for shallow components



New Loudon planer with high speed milling head

Planing machine

Considerable interest was aroused by a new Loudon planing machine built by the Scottish Machine Tool Corporation Ltd, of Glasgow. Its outstanding features are the adoption of the closed-loop type of Ward-Leonard drive

and the introduction of a self-contained milling head which can be mounted on the standard tool box slides. It thus breaks new ground, falling into a category intermediate of a planing machine and a plano-miller. Its function as a normal planing machine is not thereby impaired.

Advantages of the new drive system over the conventional arrangement include:

1. Wider speed range of motor, giving freer selection of speed appropriate to the work undertaken, whether planing or milling
2. Constant torque throughout the speed range
3. Maintenance of cutting speed under fluctuating load
4. Shockless reversal of table under controlled torque conditions
5. More rapid acceleration and deceleration of table, making for shorter cycle time
6. Simpler circuitry, reducing maintenance.

The design of the milling head is based on the use of a small diameter, carbide-tipped cutter rotating at high speed to permit a rapid table feed to be maintained. Thus large horse power values can be absorbed in cutting and the time required to machine a surface becomes comparable to that taken by plano-milling machines. Powering the head is a special two-speed motor, rated at 40/20 h.p, with an extended spindle supported in precision-grade Timken bearings. The cutter, or its adaptor, is mounted directly on the spindle nose, and consequently there can be no transmission losses and no gearing backlash that could cause tool chatter. Power supply is brought in by way of a simple plug-and-socket connection.

Spindle speeds are 700 and 350 rev/min, the speed being selected by suitably interlocked push buttons operating a direct-on-line starter. Cutters may range from about 3 in to 7 in diameter according to the duty, and table feed rates may be approximately 4 ft/min for roughing cuts and up to 8 or 10 ft/min on finishing cuts.

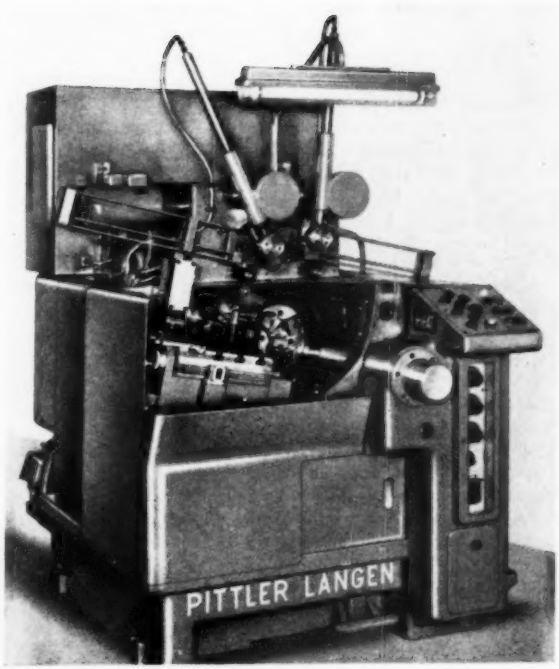
Front-operation chucking automatics

Shown for the first time were two new chucking automatics by Pittler Maschinenfabrik A.G. of Langen b. Frankfurt am Main, Germany. They were of the same capacity, turning work up to 9·1 in diameter, but were arranged in single- and double-spindle versions, designated Pifat and Pidofat models respectively.

For large batch production the single-spindle machine can be equipped with loading and unloading devices, as illustrated, to make possible fully automatic operation. This comprises two electro-hydraulically operated pick-up arms positioned respectively to the left and right above the spindle. The left arm picks a workpiece from a loading rack, swings it into position, and places it in the chuck. The chuck closes automatically, the arm withdraws to clear the spindle, and the work cycle commences. When the cycle is completed, the right arm picks the finished work from the chuck and deposits it in the discharge rack for transfer to the next adjacent machine.

The Pifat model has a turret slide with three index positions and intermediate stops for easy access to the chuck when manually loading or unloading. Speeds and feeds are individually preset for each index position. To the left of the turret slide is a cross slide that can be operated under any one of six different programmes selected by means of a plug-in switch block. These programmes include longitudinal and face copying in two directions and L-shaped and rectangular routines.

The spindle, driven by an 8 h.p. motor (or a 13½ h.p. unit for high-duty operation) has eight speeds from 56 to 1,400 rev/min controlled from the turret slide. Feed movements of slides, operated hydraulically under electrical control, are steplessly variable from 0·3 to 15·7 in/min. If required a hydraulic longitudinal copying attachment can be fitted to the cross slide.



Pittler Pifat single-spindle, front operation, chucking automatic

On the Pidofat two-spindle machine, each unit is functionally independent. It is intended for the successive machining of each face of a workpiece without intermediate stacking. The left-hand spindle has a turret slide and an overhead cross slide, while the right-hand spindle has a compound slide and an overhead cross slide. All sliding tables can be programmed by plug-in switches and all can be fitted with copying attachments.

Agents for Pittler tools are B.P.S. Machinery and Spares Co. Ltd, 245 Knightsbridge, London.

Second-operation machines

The extensive range of second-operation machines developed by the Economy Engineering Co, of Willoughby, Ohio, U.S.A, is handled by Funditor Ltd, 3 Woodbridge Street, London, E.C.1, and some models, including the "shaving" machine illustrated, are now built in Britain. All are fully automatic machines for the rapid finishing of mass-produced parts of basically cylindrical shape that can be hopper fed. An exception is a special semi-automatic machine arranged for the manual loading and unloading of parts that by reason of their shape cannot be fed from a hopper.

Typs LS-3600, illustrated, is the smaller of two shaving machines and can handle work having body diameters up to ½ in. and lengths under the head from ½ in to 4½ in. It can perform such operations as facing, turning, chamfering, grooving, necking, knurling, burnishing, and cutting-off on a wide variety of component parts for the automobile industry. These include valves, tappets, gudgeon pins, shackle bolts, cylinder head bolts, ball studs, wheel studs, and similar items, which are handled at production rates of from 800 to 2,400 per hour.

In construction, the machines are unorthodox. All the working mechanism is located above the bed to facilitate maintenance, rapid adjustment, and lubrication. Tools are

carried by rocking levers mounted in honed, hardened steel bearings and the cam rollers, of hardened and ground tool steel, have eccentric bushings which provide a coarse tool adjustment. Fine adjustment is obtained by moving the cam, ground on its periphery with a 5 deg taper, along a threaded cam sleeve. Individual variable-speed drives to the spindle, mounted in tapered roller bearings, and the camshaft provide a steplessly variable range of speeds and feeds from 800 to 2,400 rev/min and 14 to 40 rev/min respectively.

In operation, the workpieces are fed from a hopper to a carrier slide from which they are released singly, picked off by feed fingers and transferred to the spindle collet which is closed automatically. The tools are fed in by their individual cams in appropriate sequence and, on completion of the machining cycle, the collet opens and the finished workpiece is ejected into a discharge chute.

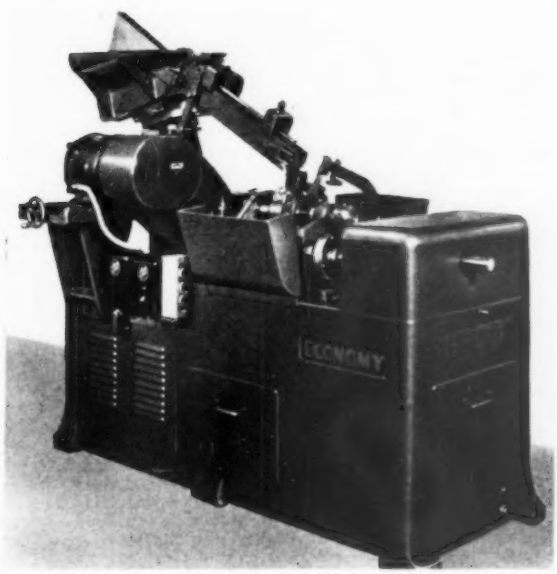
The larger machine, Type S-4300, is of similar design and has a work capacity up to 1·0 in diameter and a length of 6·0 in under the head. Its production rates are from 450 to 1,800 pieces/hr. One operator can tend several machines.

Twin-head precision lathe

Reference has been made in an earlier issue to the performance of the small Kummer double-spindle lathe for disc-like parts up to approximately 3½ in diameter.* At Olympia, Gaston E. Marbaix Ltd, London, S.W.11, the British agents for the manufacturers, Kummer Frères S.A, of Tramelan, Switzerland, exhibited the latest Model K-20. This is a logical development of its predecessor, Model MR-6020, over which it possesses a number of significant advantages.

Using a special speed cam, two speeds are available at the spindle during a single cam cycle. The changeover is automatic and enables large and small diameters on the work to be cut at favourable speeds. On some components this feature can reduce production times.

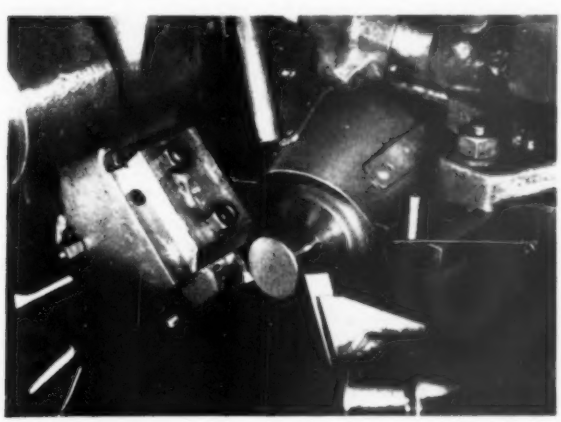
Instead of a mechanical type variable speed gear and a mechanical clutch system the new model has D.C. motors and selenium rectifiers which give stepless variation and also supply braking effort. Spindle speed can be varied while running. The motors are rated at 2·2 or 2·8 h.p. instead of 1·25 or 2·0 h.p. and twin instead of single driving belts are used. Ten speeds are provided for the camshaft.



Economy LS-3600 high speed, fully automatic, shaving machine

Kummer K-20, double-spindle, automatic cycle, precision lathe

Cam-operated, lever-mounted tools on Economy machine



Independent drives to spindle and camshaft have been discontinued in favour of driving the camshaft through the spindle. Should the spindle be overloaded and stop, the cam operating a tool slide will also stop and thus prevent damage arising. Furthermore, an increase in spindle speed will increase cam speed and thus reduce cycle time. Another device now fitted tends to reduce cycle time; a cam accelerator that raises the operating speed of tool slides during idle or non-cutting time.

To reduce setting time when changing over from one batch of work to another or when the need arises to regrind tools, the slide is furnished with a detachable base plate on which the tool blocks are mounted. One base and tool assembly can be removed and immediately another assembly, set up in the tool room, can replace it.

A further selection of tools shown at the Machine Tool Exhibition will be reviewed in a subsequent issue.

*Automobile Engineer, May, 1960.

Recent German Publications

Brief Reviews of Current Technical Books

Versuche zur Ermittlung der günstigsten Konstruktion von Kraftfahrzeugbremsen hoher Dauerleistung. (Tests to Determine Most Advantageous Designs of Vehicle Brakes for High Continuous Output.) Deutsche Kraftfahrtforschung und Strassenverkehrstechnik, No. 121.

In German, by Otto Bode, Prof. Dr. Ing. and Harro Dorner, Dipl. Ing.
Düsseldorf: VDI-Verlag G.m.b.H. 1958. 11¾ × 8¼ 26 pp. Price D.M. 15.20.

This report deals with tests carried out, at the Vehicle Research Institute of the Technical High School at Hanover, at the request of the Federal Ministry of Transport. It is a continuation of the extensive rig tests previously discussed in Report No. 117. Increasing loads and speeds lead to greater demands being imposed on brake components, particularly when dealing with continuous brake applications down long gradients. In these circumstances, the thermal capacity of the brakes depends upon their ability to dissipate heat to the ambient air, the thermal conductivity of the material and the ability of the components to store heat during intense applications of short duration.

In the report under review are given the results of rig tests carried out to ascertain the thermal capacity of the brakes when subjected to an application of 20 minutes duration, the intensity of application being just below the level that could be dangerous to the components. These tests were carried out on ten types of drum brakes, and also with two types of disc brakes, one with radial vanes, and the other with curved 15 mm wide cooling vanes cored in the cast discs. All the different brake types are illustrated and their leading dimensions are conveniently summarized in a table. The test procedure is briefly described and the results of tests are dealt with in detail by the use of numerous graphs, which add much to the value of this interesting report.

In conclusion the authors deal with tests carried out to ascertain the thermal performance of the disc brakes under actual operating conditions when installed in a Ford type 12 M car. The results of the tests are summarized at the end of the report, where the valuable and interesting points brought out are of particular use to brake and vehicle designers. In general, the body of the report contains much useful information. It would be particularly interesting to consider the possible correlation between theoretical considerations, briefly dealt with in the July 1956 issue of *Automobile Engineer*, with the results obtained by the authors of this report.

Vergleich verschiedener Verfahren zur Feststellung der dynamischen Radlasten. (Comparison of Different Methods for the Determination of Dynamic Wheel Loads.) Deutsche Kraftfahrtforschung und Strassenverkehrstechnik, No. 131.

In German, by O. Bode, Prof. Dr. Ing. P. Ochner, Dr. Ing. P. Koessler, Prof. Dr. Ing. H. V. Bruchhausen, Dipl.-Ing. M. Mitschke, Dr. Ing. and W. Becker. Dipl.-Ing.
Düsseldorf: VDI-Verlag G.m.b.H, 1959. 11¾ × 8¼. 32 pp. Price D.M. 21.50.

Interest shown by road and vehicle designers, and the governing authorities, in the interaction between vehicles and road, in terms of dynamic loads and their effect on road damage, has resulted in the development of a number of load measuring test procedures. At the Aachen Technical High School, the loads are measured by the acceleration at the axle and chassis, whilst at the Brunswick Technical High School, the load is obtained by measuring tyre deflection by determining the change of capacitance between the road surface and a probe extending downwards from the axle. The Hanover Technical High School, on the other hand, determines the dynamic load in terms of axle distortion.

In the first part of the report, by Bode and Ochner, tests carried out to determine the comparability of results obtained with these three different methods are dealt with in considerable detail. The results are critically examined and attention is drawn to the possible degree of inaccuracy and the pitfalls that might be encountered with each system. Next, Koessler and Bruchhausen deal with comparative tests on the methods developed at the Darmstadt, Munich and Brunswick Technical High Schools. In the first, use is made of suitably strain-gauged wheel hubs, while in the second, the dynamic load, in terms of lateral bulging of the tyre, is recorded by means of rotary potentiometers operated by probes carried on a frame surrounding the lower portion of the wheel. The third, the Brunswick method, is identical with the first. Again the results of the tests are considered in detail and the advantages and disadvantages of the different methods are conveniently summarized in tabular form.

Finally, Mitschke and Becker deal with tests carried out to compare results obtained by using the Brunswick and Munich load-measuring methods, and also an earlier Brunswick method, in which the dynamic load was determined by measuring lateral tyre bulging in terms of capacitance change between the tyre and a probe carried at some distance from it, and mounted on the axle. The results, which are considered in some detail, lead to the conclusion that a good correlation has been achieved and that the three methods are substantially equally reliable. It is becoming obvious that the increasing traffic density, in terms of numbers of vehicles and the proportion with heavy axle loads, will make it highly desirable to extend the scope of research to the interaction between vehicles and road with particular reference to design parameters such as sprung and unsprung masses and inertias, the characteristics of springs and tyres, and damper characteristics. In these respects, this report will be of considerable assistance so far as the determination of dynamic loads is concerned.

Über die Seitenführungskraft von Personenwagen—Reifen. (On the Side Force of Automobile Tyres.) Deutsche Kraftfahrtforschung und Strassenverkehrstechnik, No. 133.

In German, by F. Gauss and H. Wolff.
Düsseldorf: VDI-Verlag G.m.b.H, 1959. 11¾ × 8¼. 26 pp. Price D.M. 17.50.

Since the lateral stability of fast motor cars is to a great extent determined by the relevant tyre characteristics, it is of importance to ascertain the effect of tyre design features and air pressures upon tyre characteristics affecting factors such as cornering forces and skid resistance. To facilitate these investigations, a suitable test rig was built at the Research Institute for Motor Car Engineering and Vehicle Engines, at the Technical High School, Stuttgart. A considerable number of tyres have been tested there at the instigation of the German tyre industry and the Federal Ministry of Transport. The report deals with the test rig and its instrumentation, and the preliminary tests carried out to clarify the influence of certain variables such as drum surface finish and speed. It then gives the results of tests carried out on very small tyres, for miniature cars, and on tyres ranging from 13 in to 16 in diameter. In the work there is a wealth of information presented in the form of some eighty graphs of tyre characteristics.

Massnahmen gegen Belästigung und Gefährdung durch Abgase von Ottomotoren. (Measures to Combat Annoyance and Danger due to Exhaust Gases of Otto Engines.) Deutsche Kraftfahrtforschung und Strassenverkehrstechnik, No. 128.

In German, by H. Hontschnik, Dipl.-Ing. R. Marterstock, Ditl.-Ing. and A. Reuter, Dr.
Düsseldorf: VDI-Verlag G.m.b.H, 1959. 11¾ × 8¼. 36 pp. Price D.M. 23.50.

This report was prepared by the Battelle Institute, Frankfurt, at the request of the Federal Ministry of Transport. It is a summary of the present state of knowledge of the subject, and is an endeavour to avoid unnecessary duplication of effort. Consequently, the subject matter is divided into five broad subjects: they are, applied investigations relating to the analysis of exhaust gas, the composition of exhaust gases, secondary manifestations of exhaust gases and their components in the atmosphere, methods of influencing exhaust gas composition, and a discussion of promising research work likely to eliminate the implicit dangers and annoyance caused by petrol engine exhaust. Each sub-heading is a reference to a paper previously published: some 260 are briefly reviewed in the last 16 pages of the report, by Miss Ursula Mayer, although her name does not appear under the title of the report. The whole work is a thorough and useful summary of the development in this field up to 1959.

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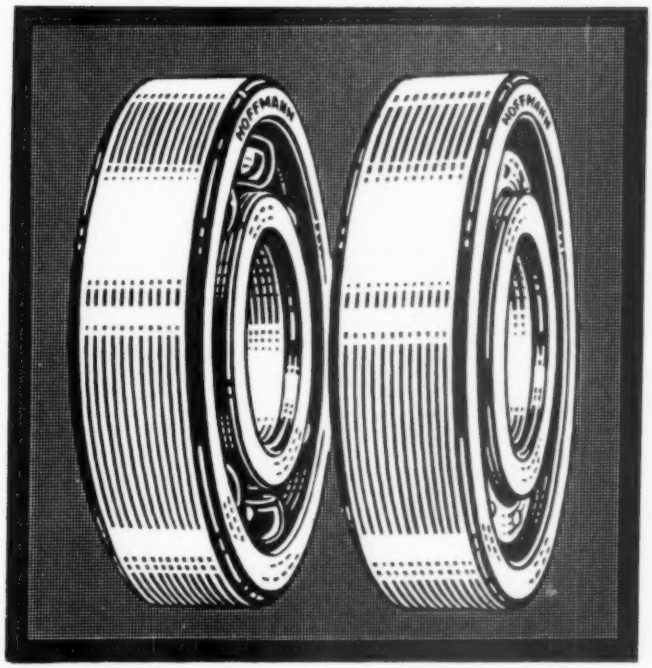

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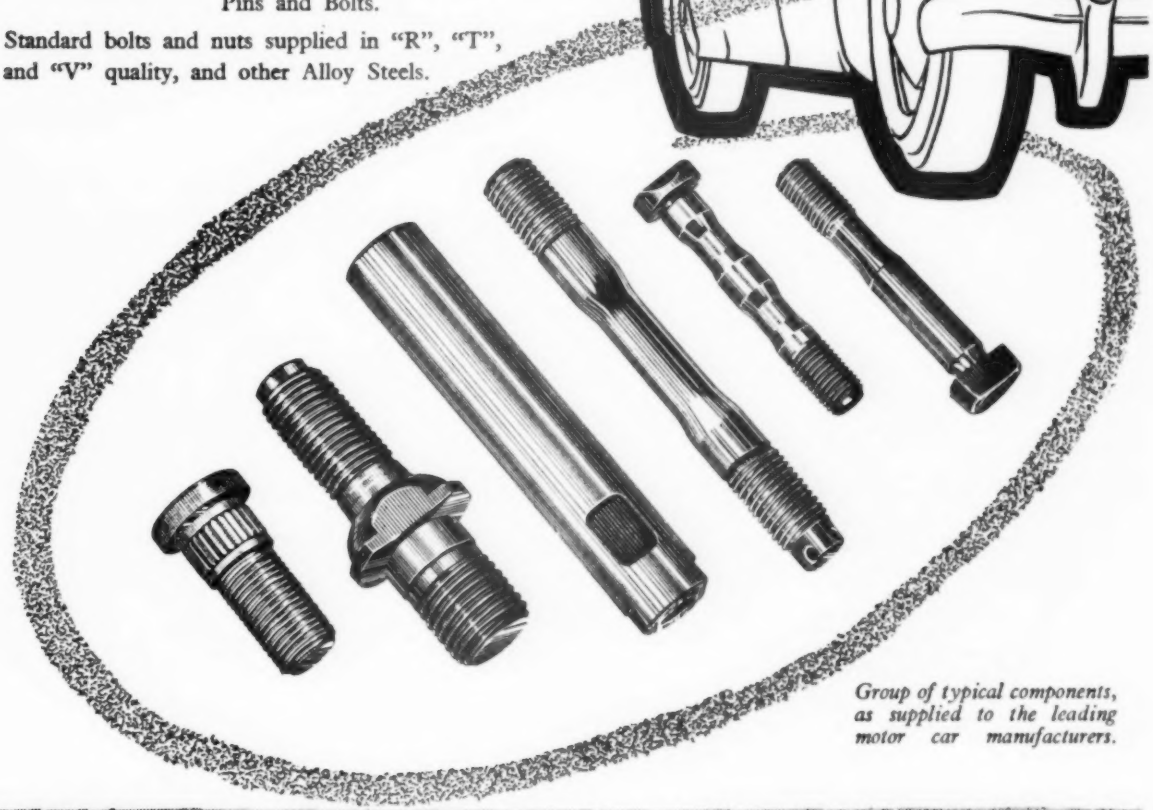

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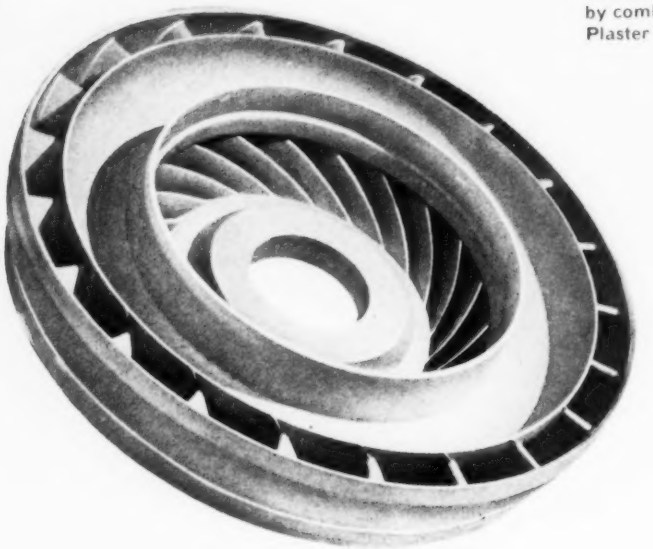

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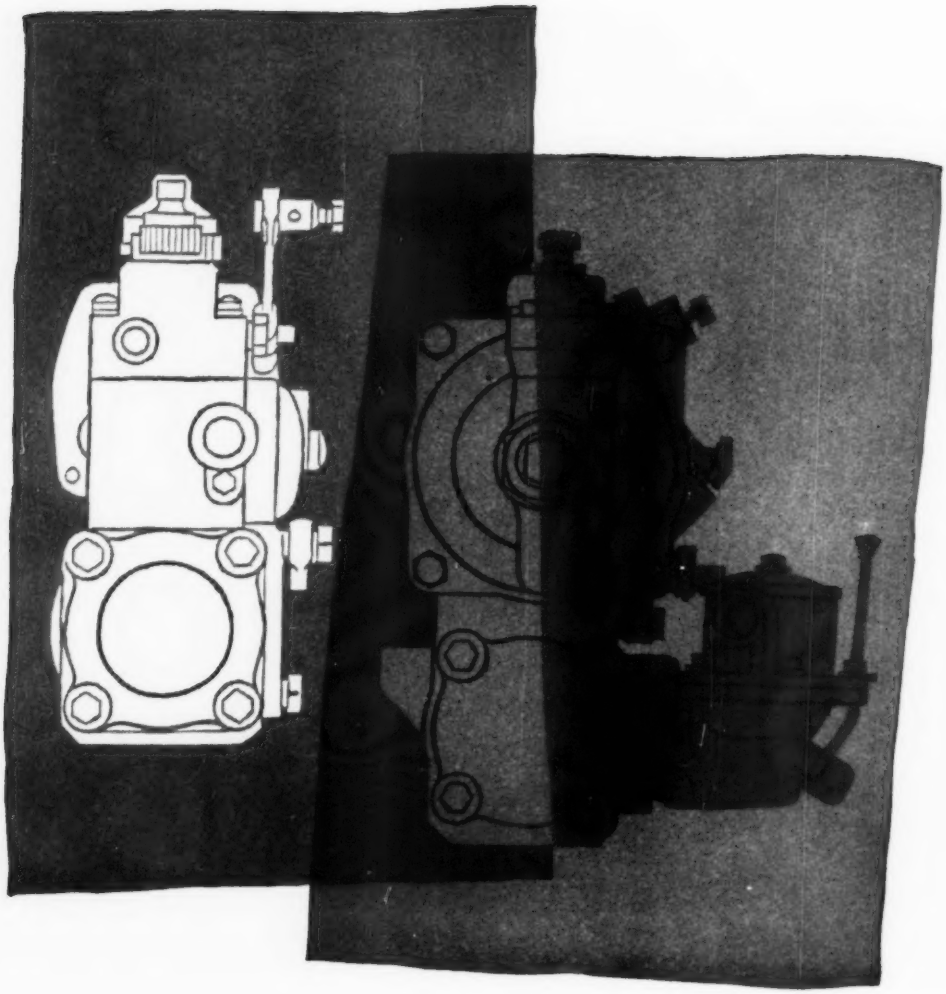

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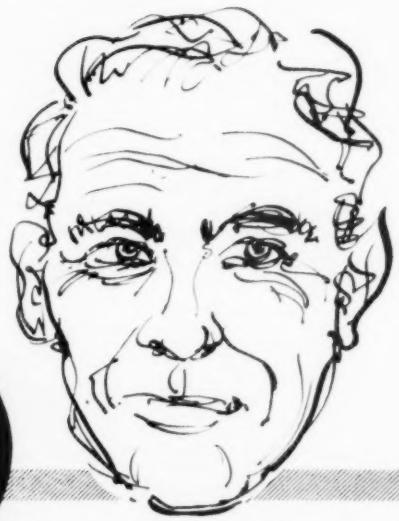

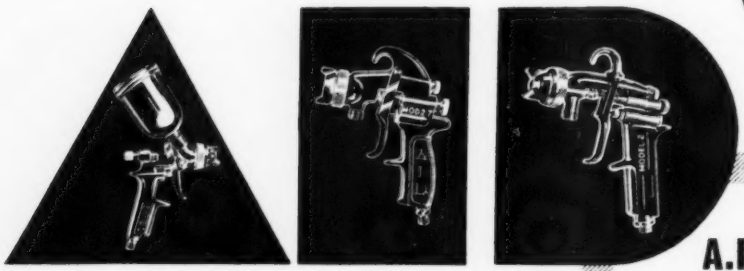

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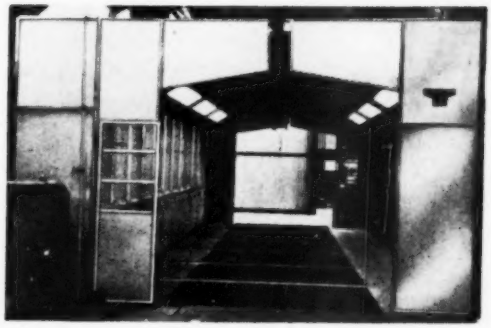

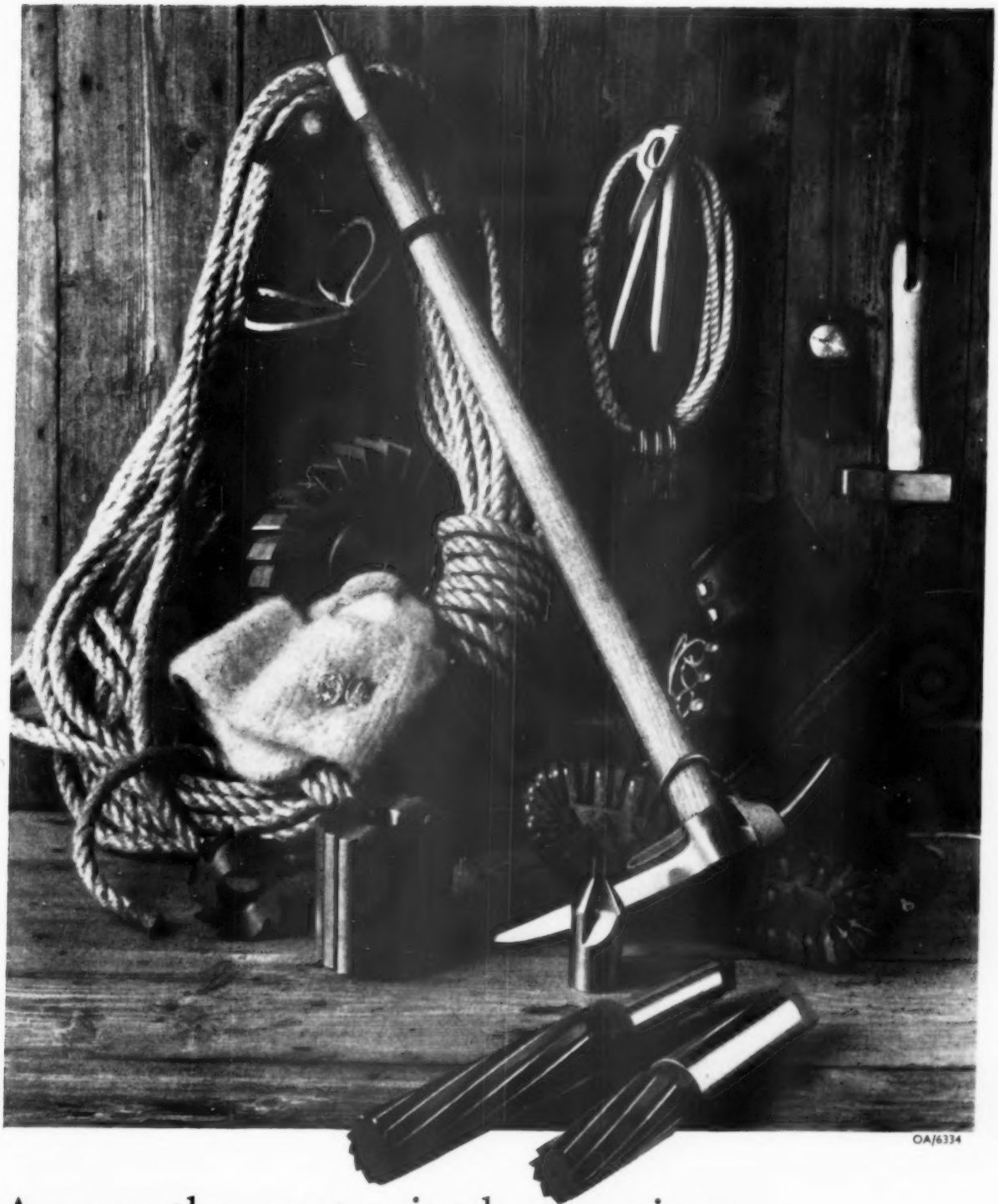

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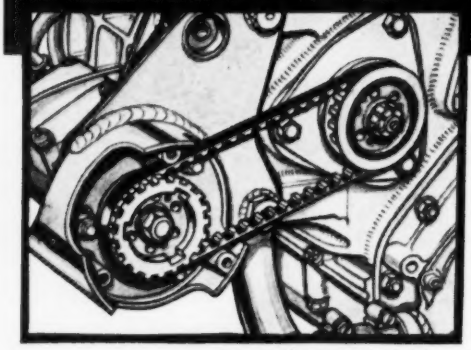

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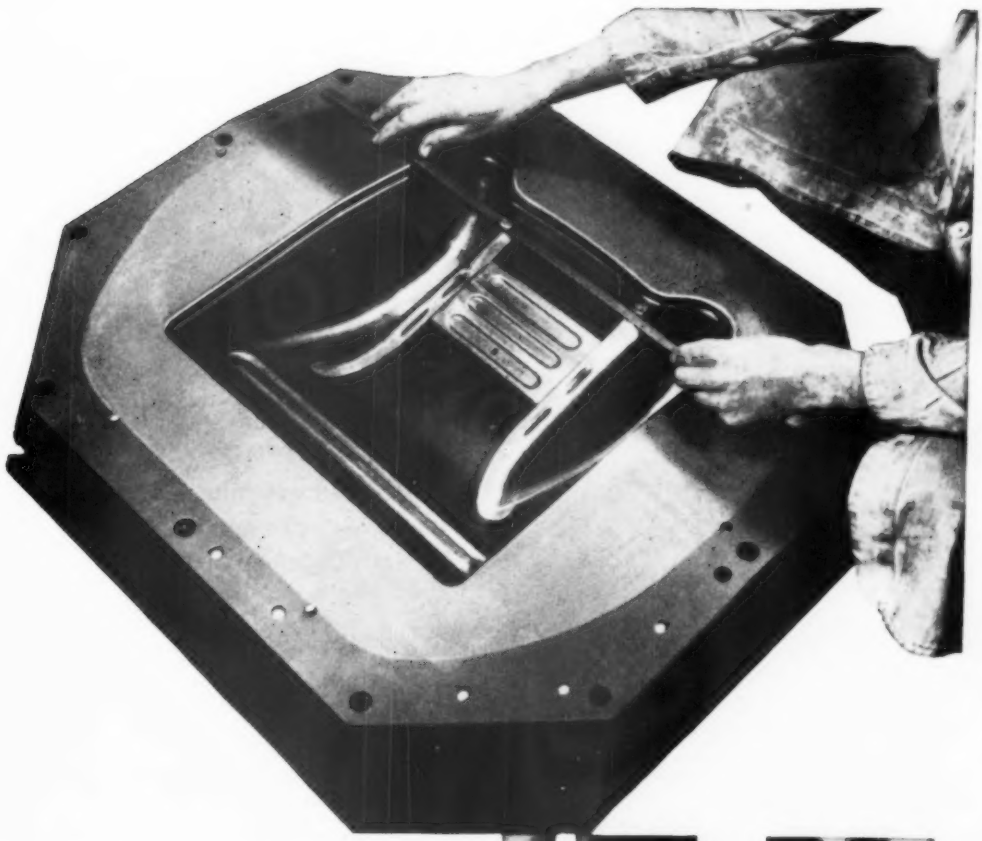

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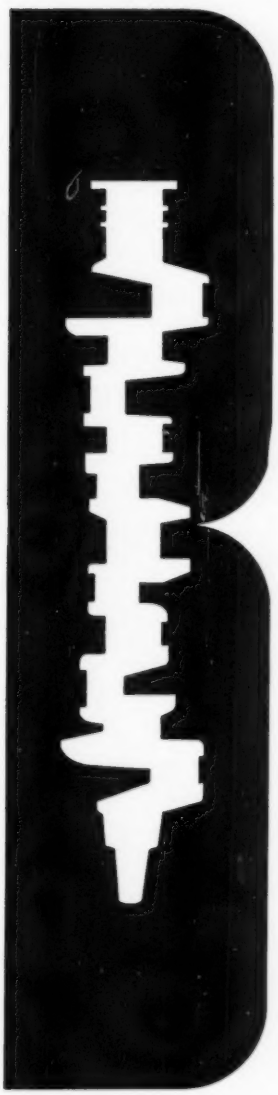

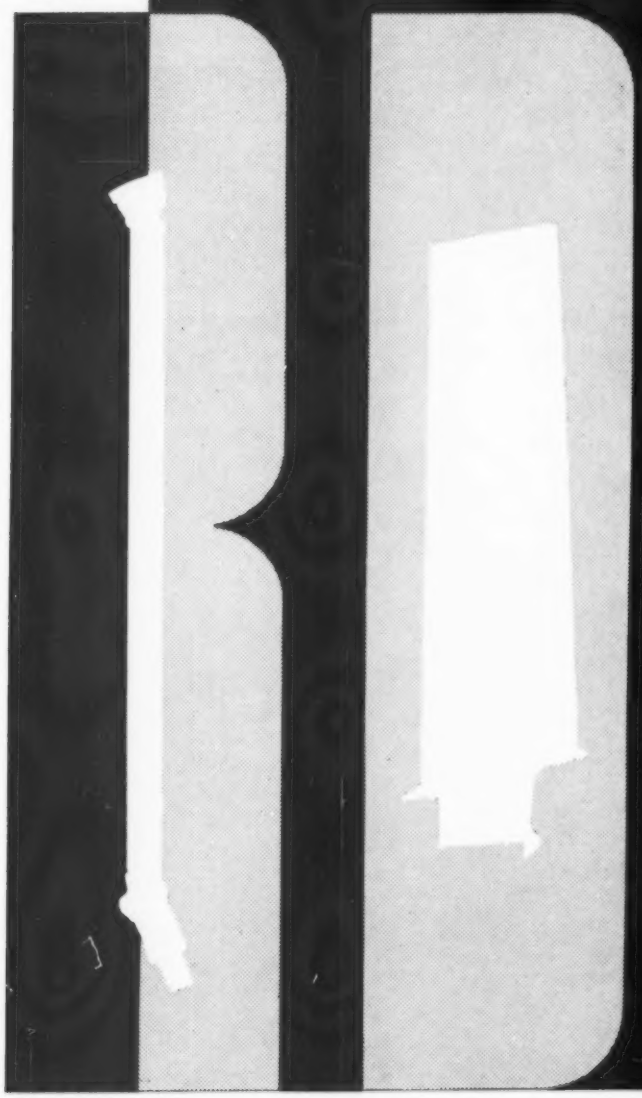

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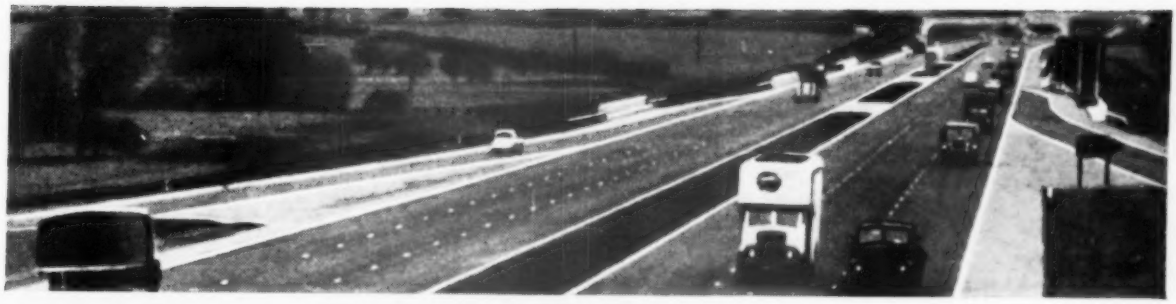

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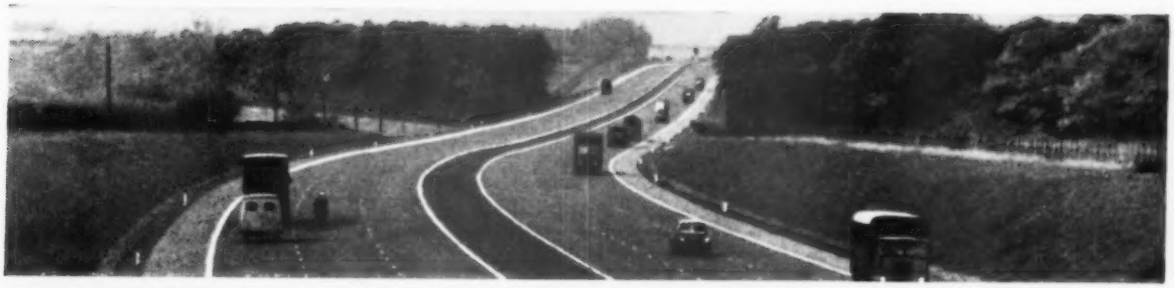

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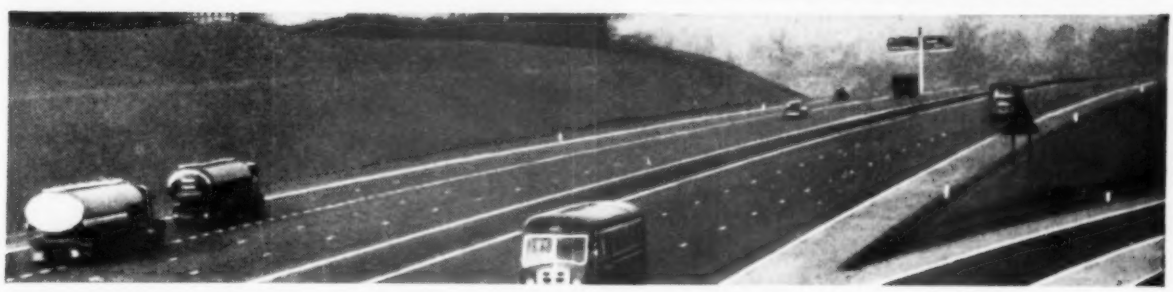

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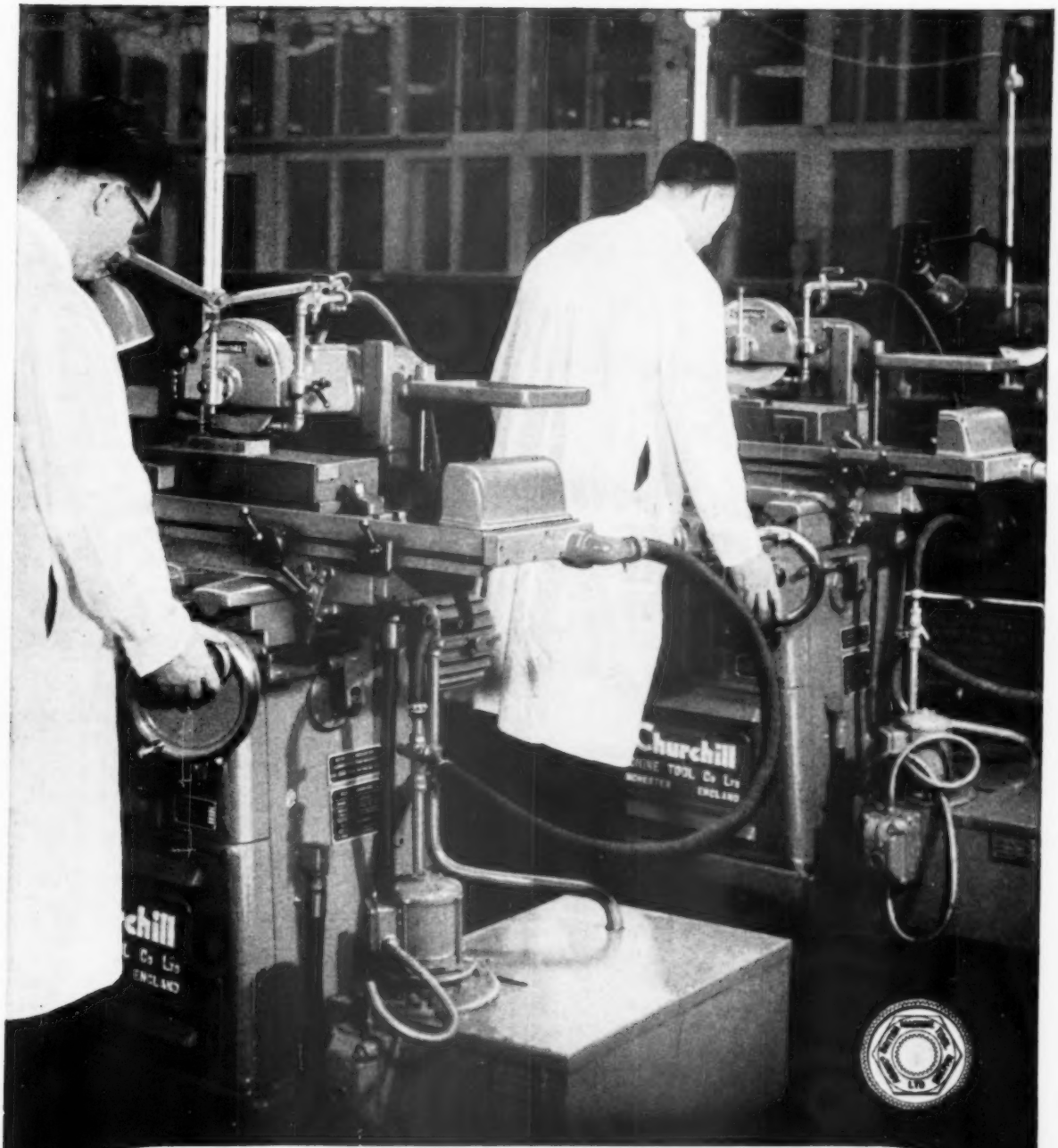

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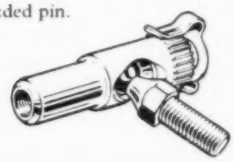

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Lima, 9th April, 1957

PERUVIAN OMNIBUS COMPANY LIMITED

J. BLUME T.

Principal of the Transport Department

The undersigned, PUBLIC NOTARY AND COMMISSIONER FOR OATHS, CERTIFIES that Mr. JUAN BLUME TRAVERSO, proving his identity with his electoral papers number six hundred fourteen thousand five hundred and ninety four and his military papers number eight hundred and seventy seven thousand six hundred and sixty two, was present in the offices of the aforesaid Public Notary, with the object of having legalised his signature in the DECLARATION which he has signed as Technical Principal of the Transport Department of the Peruvian Omnibus Company Limited, ratifying before me the said declaration which he now repeats and says as follows: "Herewith we wish to certify that Omnibus number two, of "SCANIA VABIS" make, Motor number sixty two thousand one hundred and seventy nine, Chassis number ninety one thousand nine hundred and seventy, which operates on the Lima-Ica Line, has run one million and two hundred thousand kilometres without it being found necessary to dismount the engine for repair", which he signs again in my presence, in Lima, on the thirteenth day of the month of April of the year one thousand nine hundred and fifty seven.

J. BLUME T.

DR. DANIEL CESPEDES
NOTARIO PUBLICO Y DE HACIENDA

This is a translation of an affidavit drawn up by Dr. Daniel Cespedes, Notario Publico y de Hacienda.

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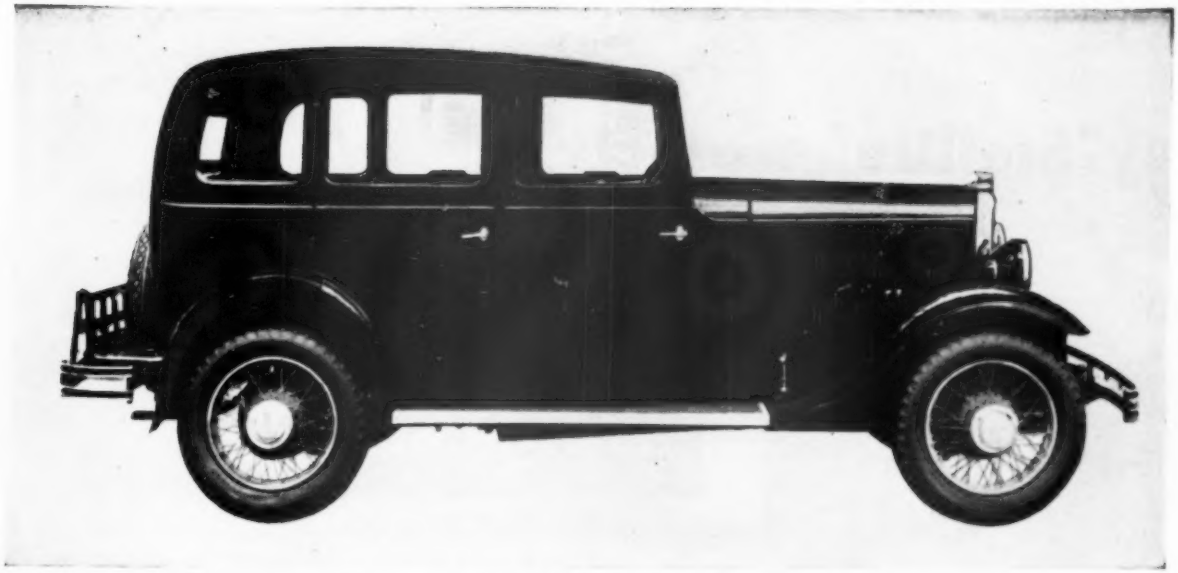

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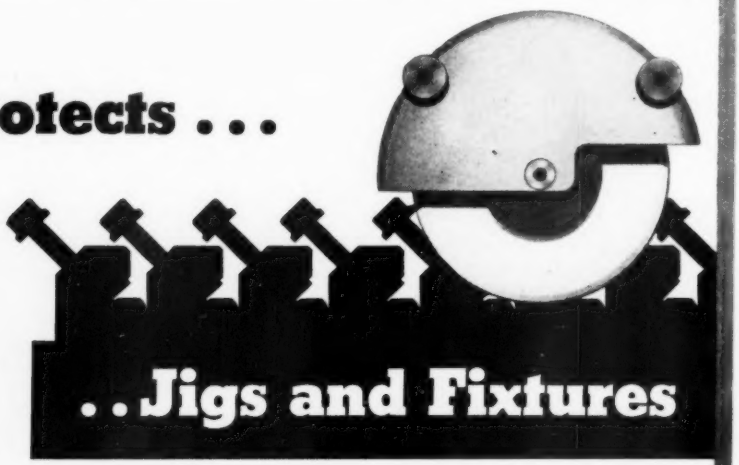

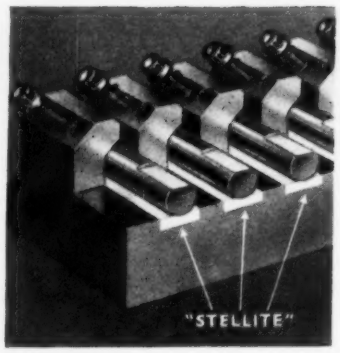

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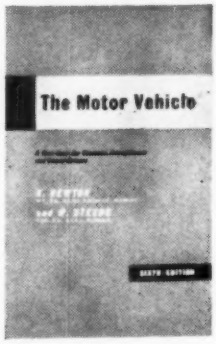

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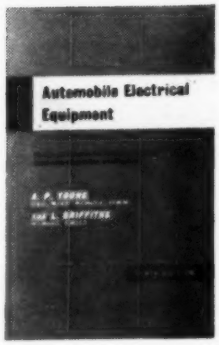

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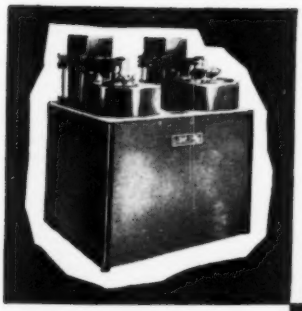

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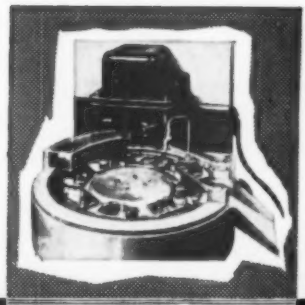

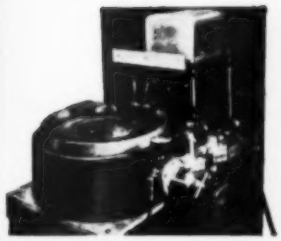

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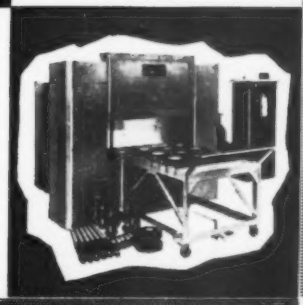

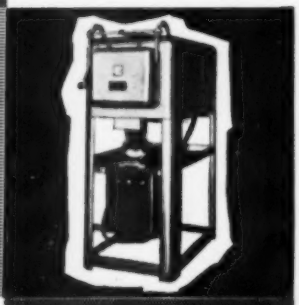

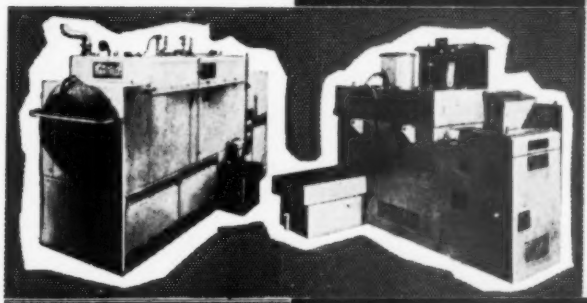

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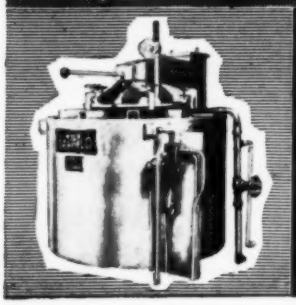

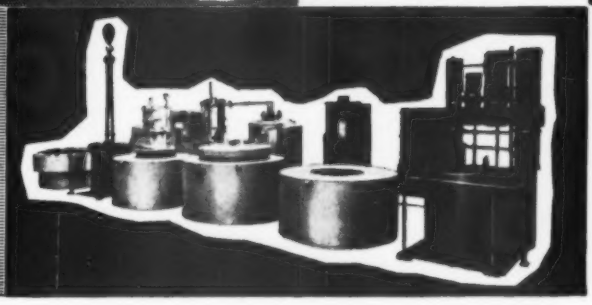

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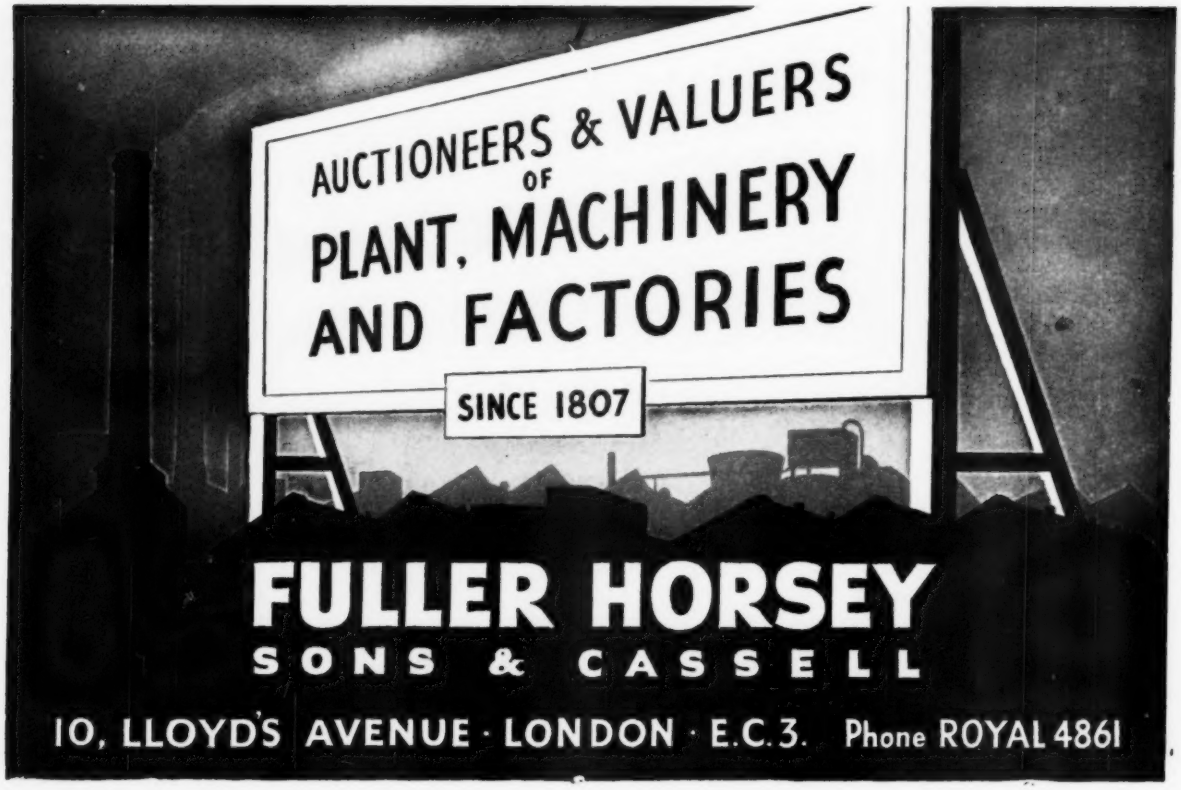

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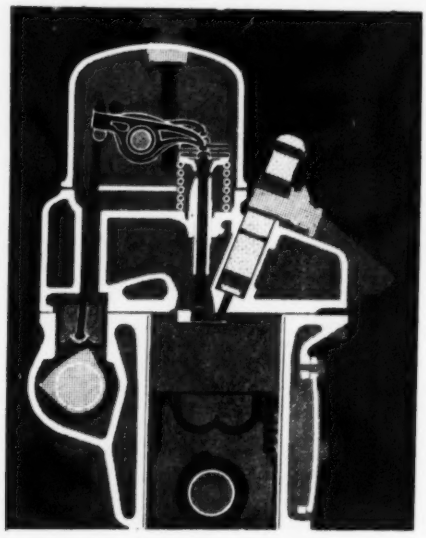

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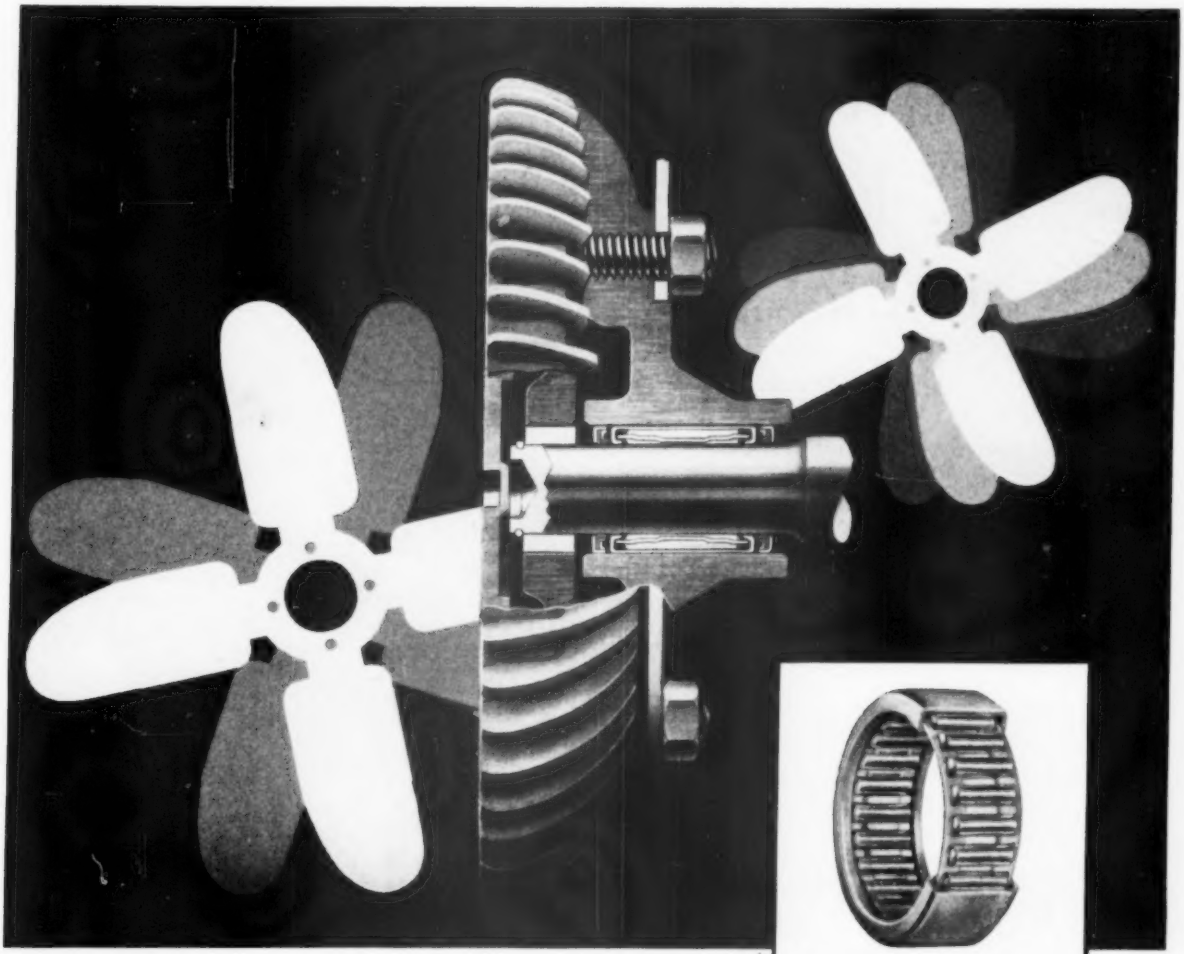

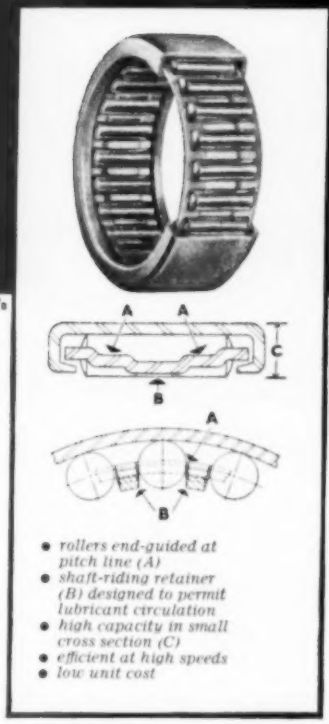

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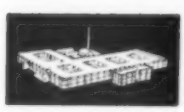

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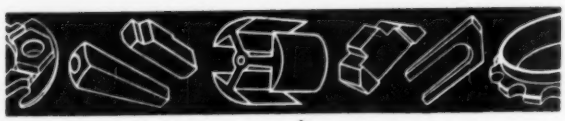

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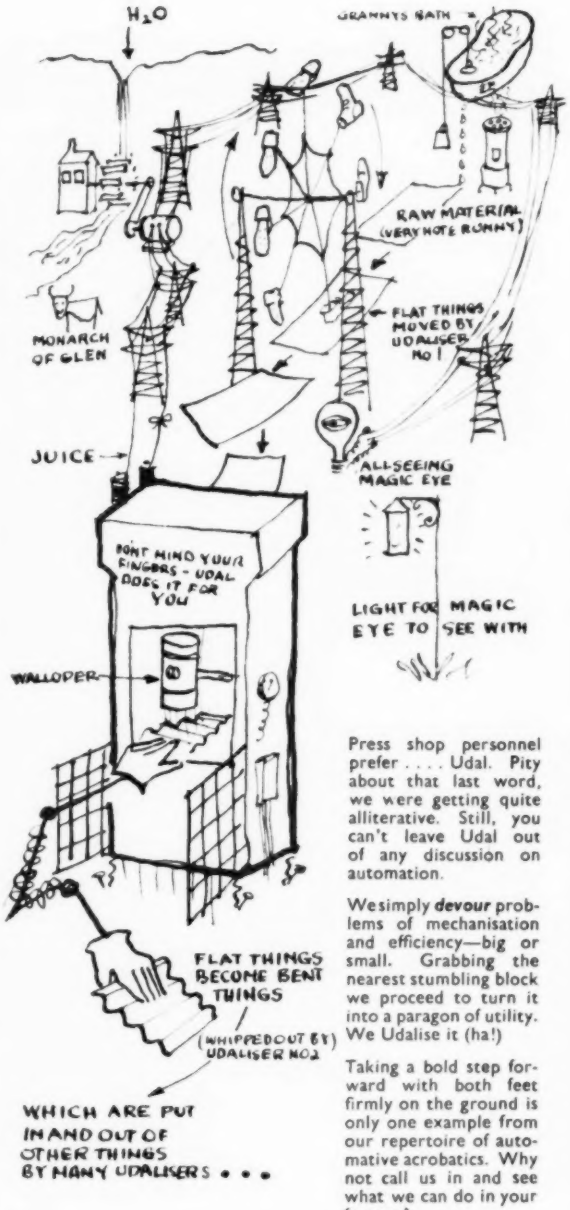
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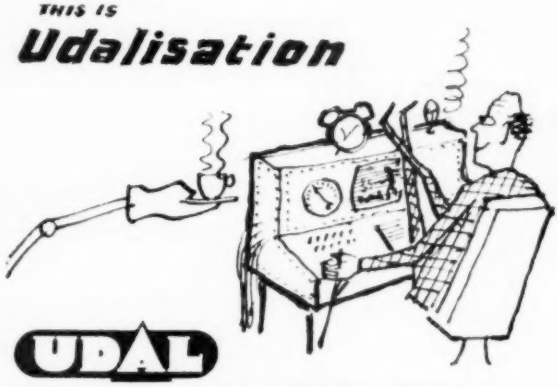

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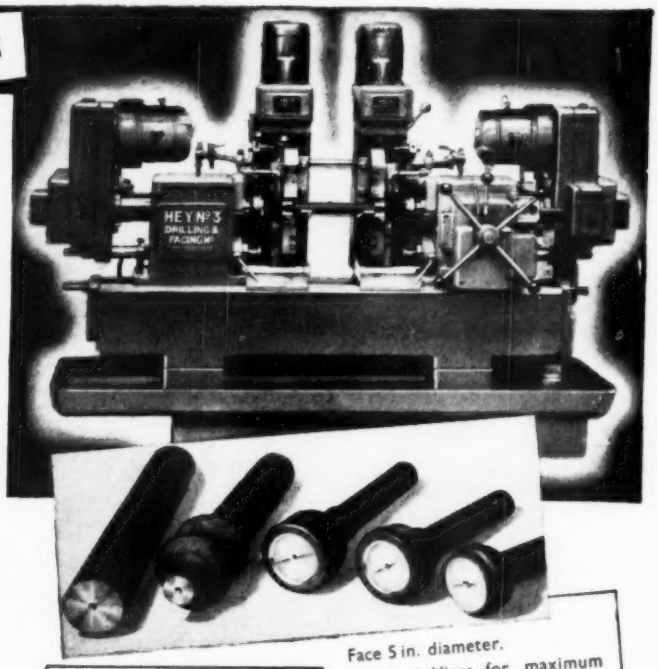

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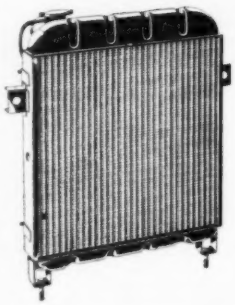

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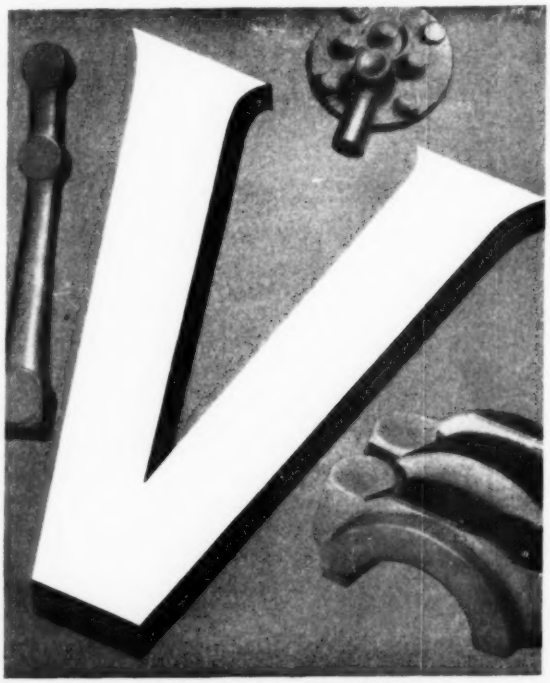

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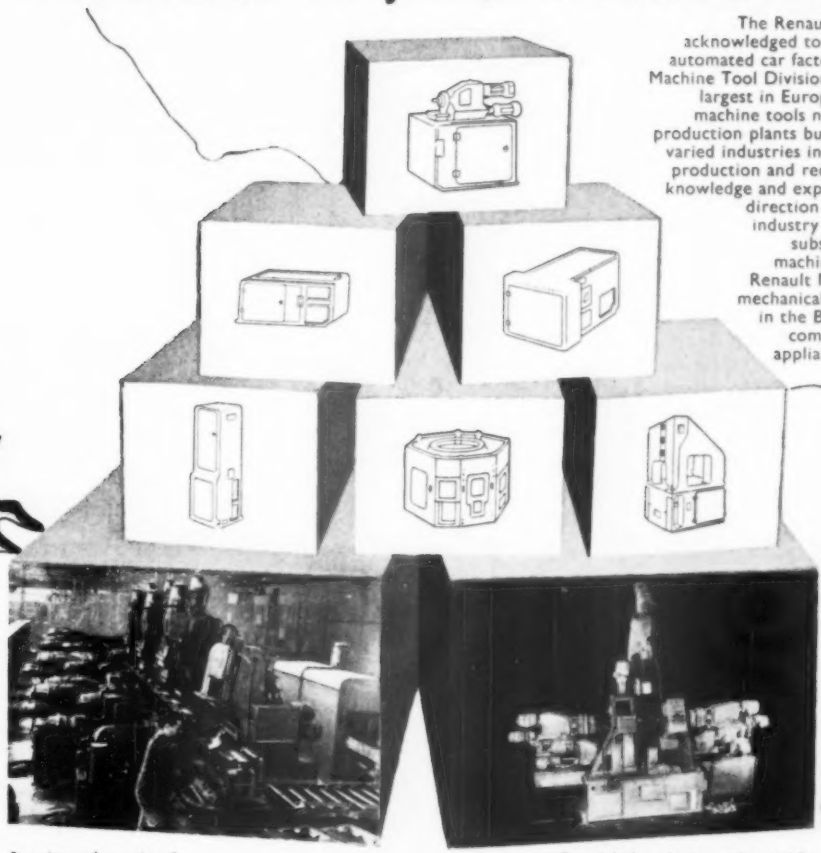

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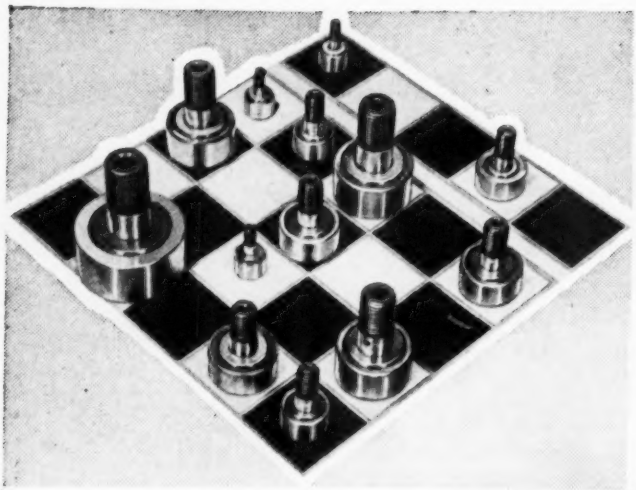

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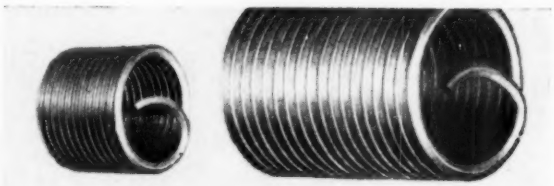

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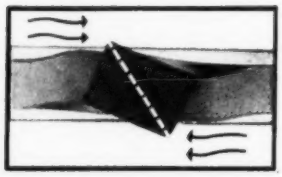

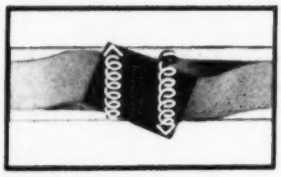

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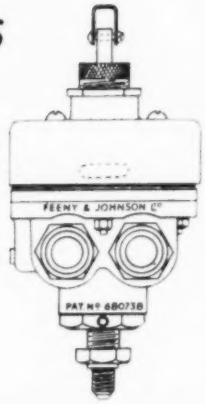

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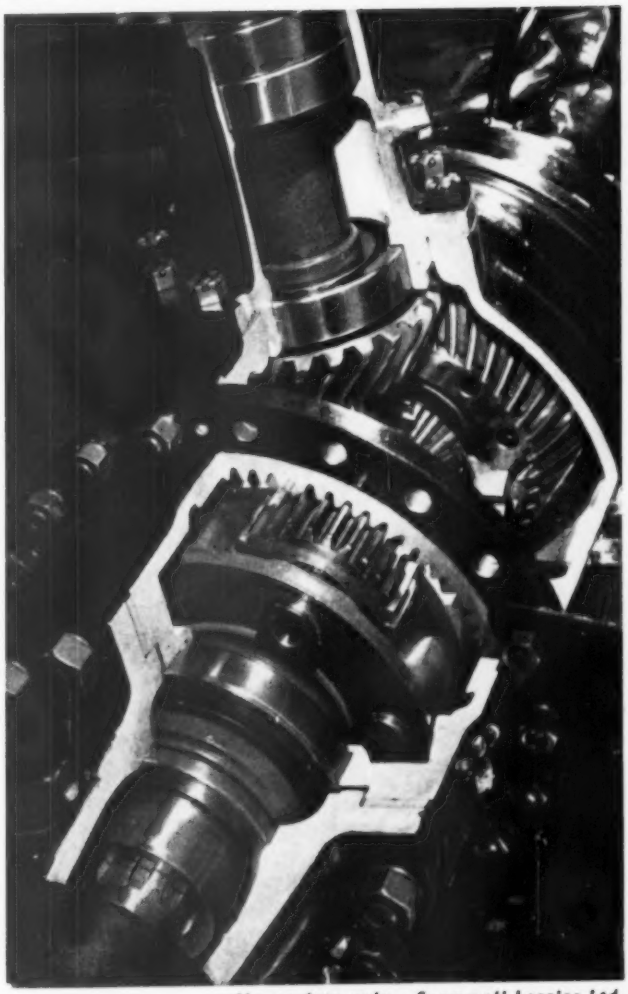

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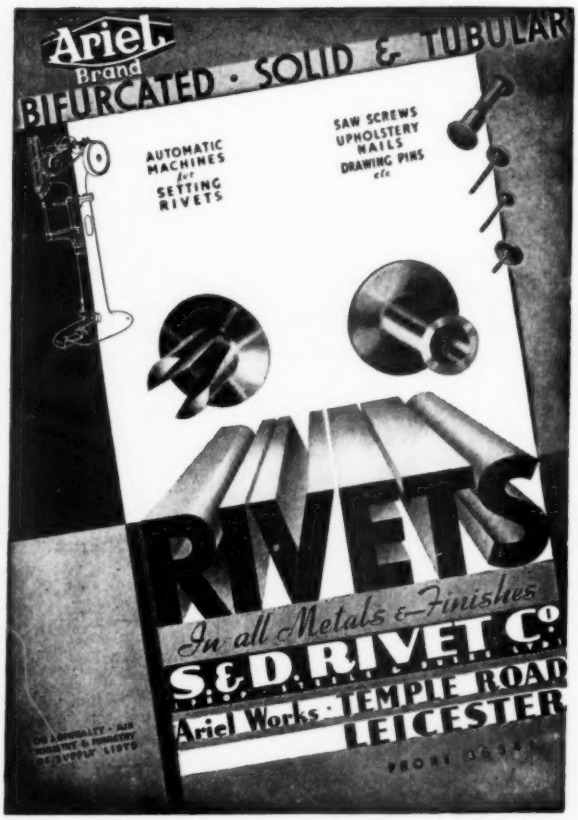

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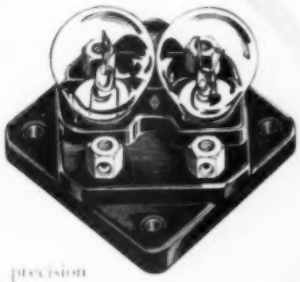

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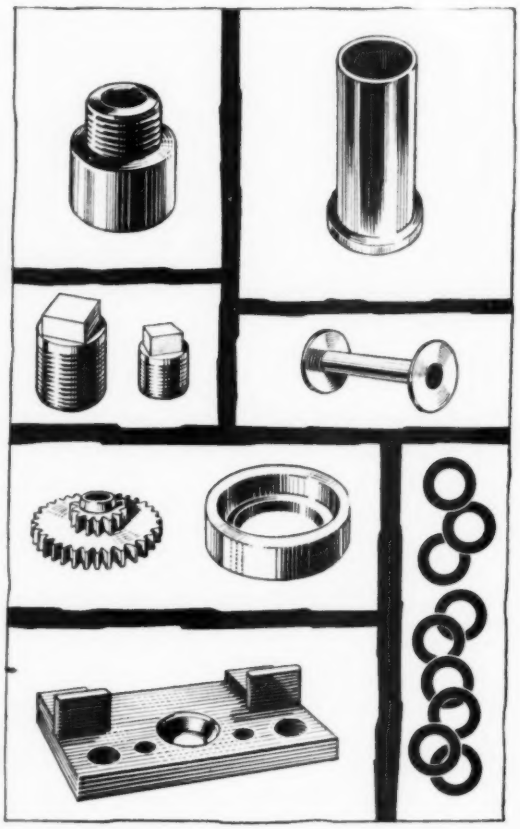

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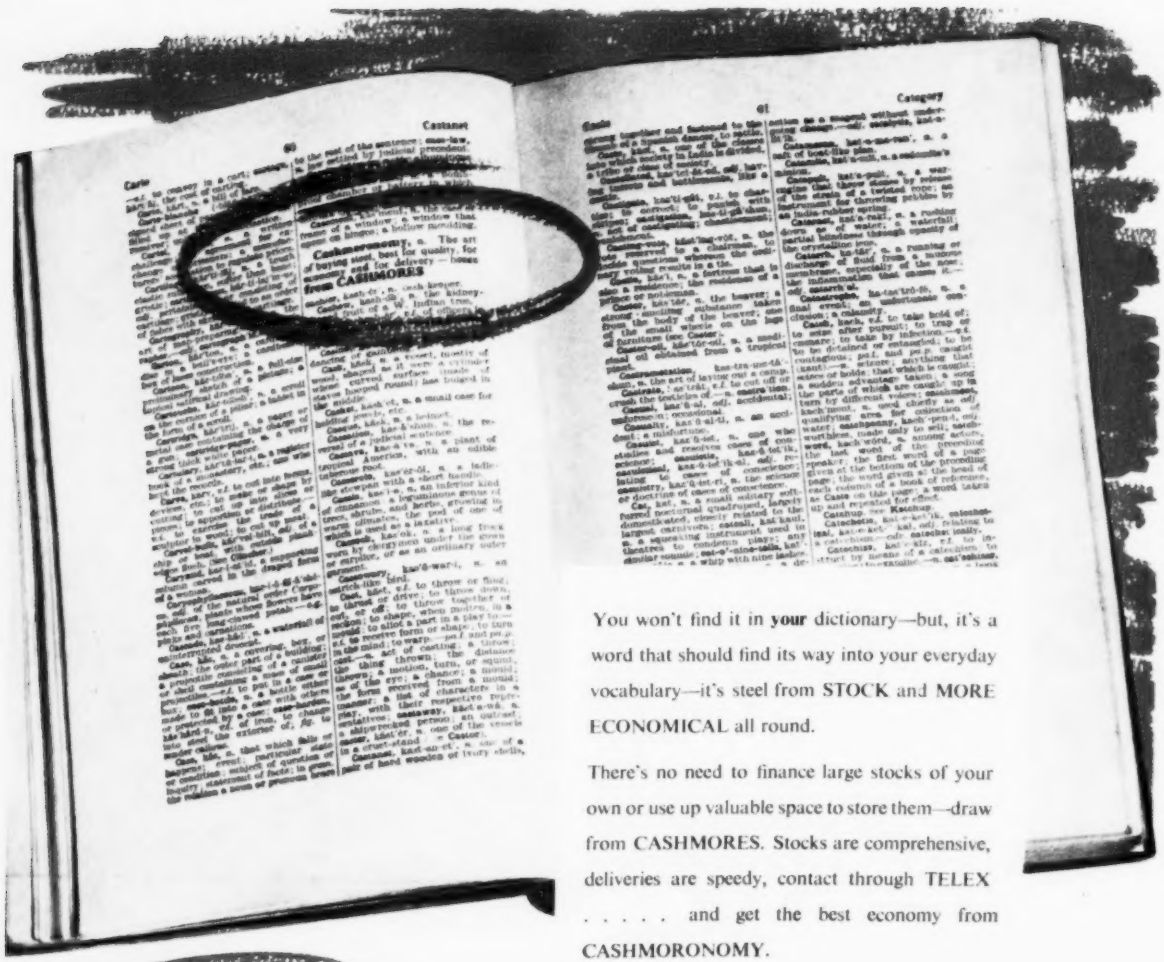

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